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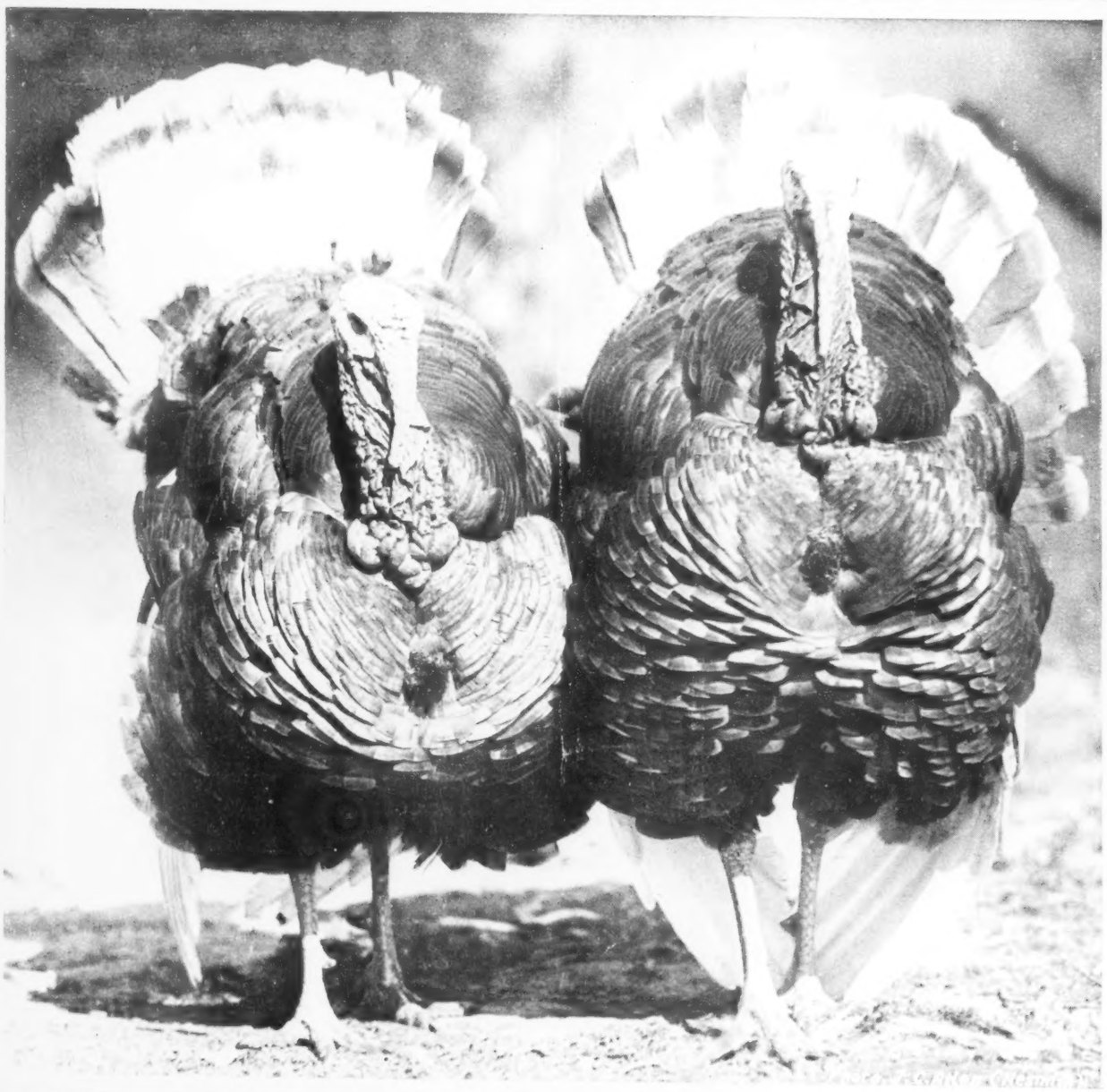
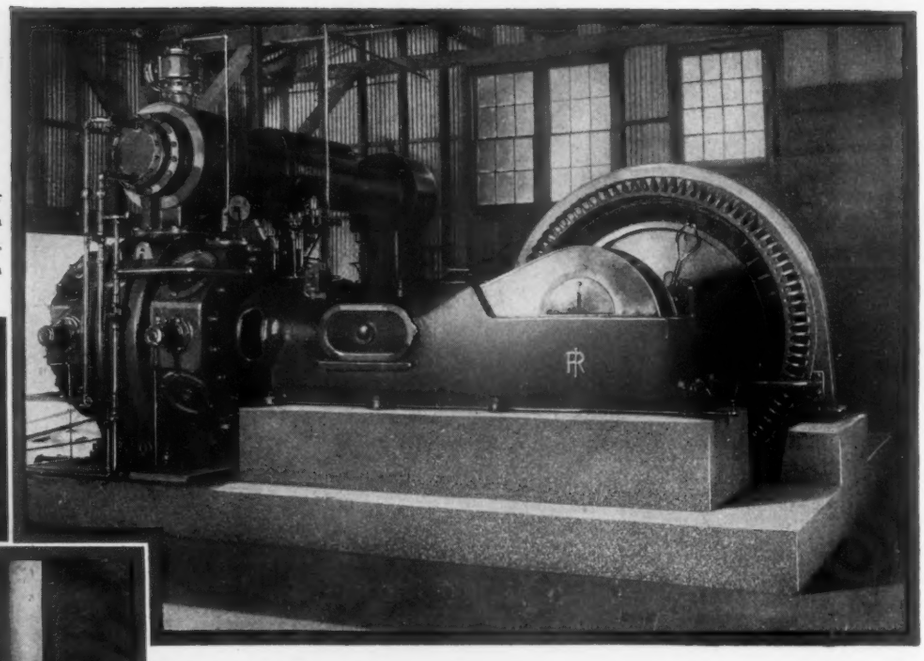
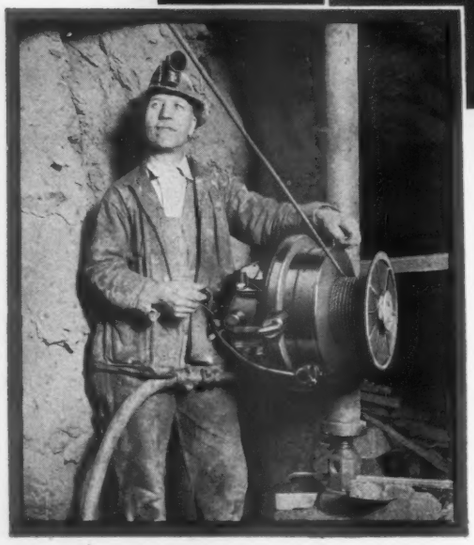




One of four I-R Air Compressors at Alaska Juneau—a 4,000 cu. ft. unit driven by a 750 h.p. motor.



Ingersoll-Rand "Utility" single and double drum Air Hoists, and electric double drum "Tugger" Hoists are great labor savers in many of Alaska Juneau's underground operations.

Drifting, Bulldozing and Stoping are carried on with I-R drills exclusively.

Air works 24 hours a day at Alaska Juneau

Ingersoll-Rand is glad of this opportunity to pay tribute to Alaska Juneau's engineering staff for the outstanding economies achieved in their operations.

12,000 feet of tunneling and raising . . . 46,000 square feet of undercutting . . . 4,000,000 tons of gold ore . . . all in one year . . . is indeed an accomplishment.

Ingersoll-Rand equipment including I-R-SKF drill steel is used extensively at Alaska Juneau. Its dependable service in supplying compressed air and in putting it to work in many operations has contributed much in realizing high tonnage at low cost.

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As It Seems To Us

OUT OF THE RUCK

MUCH confusion of thoughts exists as to the outlook for better economic conditions in the United States in the near future. Mired down by a pessimism born of repeated and prolonged disappointments and reverses, many persons can see only clouds on the horizon. Here and there an optimist, remembering that the curve of progress has veered ever upward and that the deepest valleys are between the highest peaks, visions a more glowing prosperity than we have ever previously known. Between these two extremes of opinion stand the great majority of the people, a little bewildered by it all, and resigned to plodding along and trusting that some Moses will one day appear to chart a path out of the wilderness.

At such a moment when there is little agreement as to what is in store for us, it is comforting and reassuring to note that the way has been cleared or is rapidly being cleared for five major construction projects in various sections of the country that call for combined expenditures of more than three quarters of a billion dollars. The undertakings referred to are the St. Lawrence Waterway, the San Francisco Bay Bridge, the Los Angeles Metropolitan Aqueduct, extensive riverway improvements in the Chicago area. and the Thirty-Eighth Street Vehicular Tunnel from Manhattan to New Jersey. The improvements near Chicago are actively underway, and three of the other jobs are rapidly nearing the construction stage. The purpose of every one of these enterprises is to facilitate the movement of persons and commodities. Obviously, the engineering brains that conceived them worked on the theory that we are going forward instead of backward; that commercial intercourse will soon demand more and better avenues of travel; in short, that the country will wake up some morning minus its headache and find the same old sun shining down on a busy, cheerful, purposeful people.

A VALIANT EFFORT

IN characteristic John Bull fashion, railroads in Great Britain are meeting a crisis with drawn sword and armor agleam. Sorely harassed by the depression and by bus competition, the rail carriers are striking back. Instead of retreating from a dual foe, they are lashing forth in strong attack.

In the face of diminishing receipts, timetables have been continually revised to speed up service and win back lost business. Roadbeds and rolling stock have been improved, rights of way have been widened, and ambitious programs of electrification have been launched. Rival roads are joining forces to combat common enemies. The most outstanding instance of this nature is evidenced by the recent report of the government railroad pool committee which sanctions an agreement between the London Midland and Scottish Railway and the London and North Eastern Railway. These lines serve the industrial belt lying between London and Scotland, an area which contains most of the important coal mines, steel mills, cotton mills, and manufacturing plants. They have now entered into a 50-year compact to divide receipts on virtually all classes of haulage from all competitive services, such as duplicating lines between cities.

Most spectacular of all the movements is that to increase train speeds. Elsewhere in this issue is an account of the new schedule of the Great Western Railway between Swindon and Paddington which calls for covering 77 miles in 61 minutes. The Great Western claims to be the fastest line in the world. Each day 68 of its trains travel 5,500 miles at an average speed of 55 miles an hour. Twelve of them maintain a pace of better than 60 miles an hour. During the past two years schedules have been revamped on four occasions to reduce running time. Up to last July these revisions had lopped off 2,752 minutes daily in the aggregate. At that time, fresh outbursts of speed cut an additional 6,553 minutes from the combined daily timetables. Considered as a unit, trains now negotiate their daily schedules in about 10,000 minutes less than they did in 1929. In the course of a year the saving reaches the amazing total of 60,225 hours—the equivalent of 2,500 days.

The three other principal railroad systems in Great Britain have made similar, though less pronounced, conservations in passenger schedules. These accelerations of service have pinched the government in an unexpected way. The General Post Office, which operates all British telephones, complains that expansion of this utility has been throttled because mail posted anywhere in the country reaches any other point not later than the following day.

Railroad freight service has also been remarkably quickened. As an example may be cited the reduction of 2,552 minutes a day in schedules of the London Midland and Scottish Railway. One-day transit is in force for all classes of goods between important centers of the country.

The Great Western and Southern systems have entered into a pooling agreement where their lines overlap in Cornwall and North Devonshire. Despite relatively short runs, the Southern has lowered daily passenger schedules a total of 1,272 minutes. This road runs nearly 200,000 trains monthly, and recently set a record by bringing all of them to their destinations on an average of only 30 seconds late. The Southern has electrified all its lines within 30 miles of London.

EVOLUTION AND PROGRESS

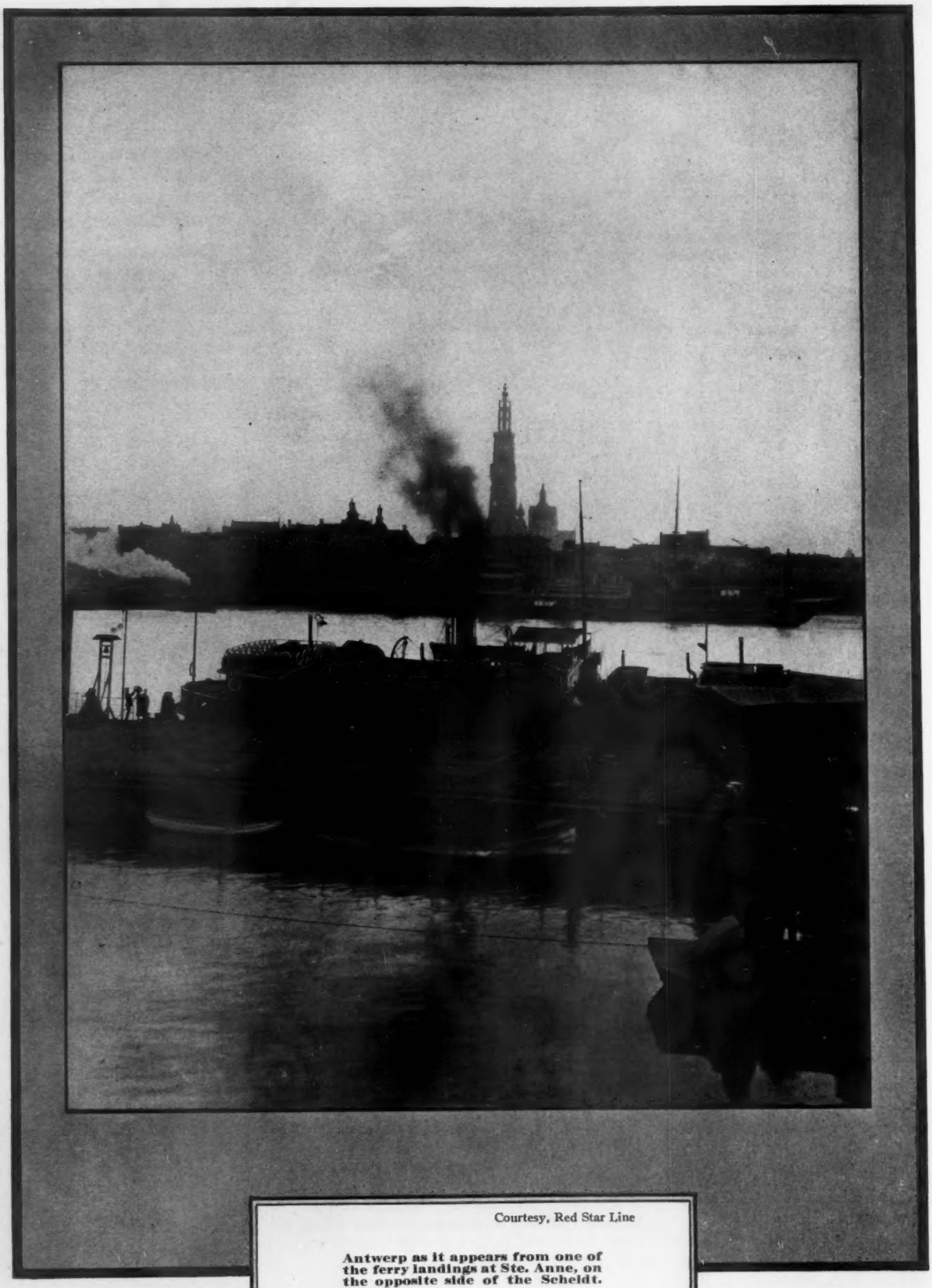
THE now outmoded piston-type rock drill was mounted on a tripod—a three-legged structure that permitted pointing the drill in practically any direction. The outfit was hard to manage and created the skilled drill runner, who was able virtually to dictate the amount of drilling per shift.

The Lake Champlain branch of the Erie Canal and the Livingston Channel in the Detroit River brought forth the drill wagon—mounting a 5½-inch piston drill in a derrick with a 15-foot feed and having a turntable which allowed the drilling of three holes spaced on 5-foot centers from one set-up. The turntable drill wagon was supplanted by the drifter-type drill on a wagon mounting for drilling blast holes to depths as great as 30 feet. Three-wheel support and 10-foot feed are customary.

This evolution in drills and mountings has been accompanied by greater accomplishment. From an allowable 45 feet of hole per day with piston drills in New York, the performance jumped to 80 feet with "Jackhamers." Today a drifter, on wheel mounting, drills 200 feet a day in New York rock. In some places it has drilled as much as 1,000 feet in eight hours. Air hoists handle the long, heavy steels. The over-all result is more work done with less human effort.

Similar progress has been made in equipment for mining and for tunnel driving. Columns and arms are still used, but drills are more powerful and they can now be obtained with an automatic feeding device which obviates cranking. Carriages which would permit the massing of a group of drills against a breast and eliminate the need for setting up and taking down mountings and drills before and after blasting were rejected by piston-drill users some 30 years ago. Practically unchanged, they were adopted for driving the Moffat and Cascade railroad tunnels twenty years later. Readers of these pages are familiar with recent developments along this line as represented by the huge carriages used at the Hoover Dam and in the several bores through Breakneck Mountain.

Thus, both drills and drilling technique have changed profoundly. The old-time hard-drinking, hard-fighting drill runner has been effaced from the picture. In his place is a steady, industrious operator—less picturesque, but more productive. Speed of operation is today the watchword, and studious, purposeful young men keep tabs on developments, never missing a chance still further to improve performance.



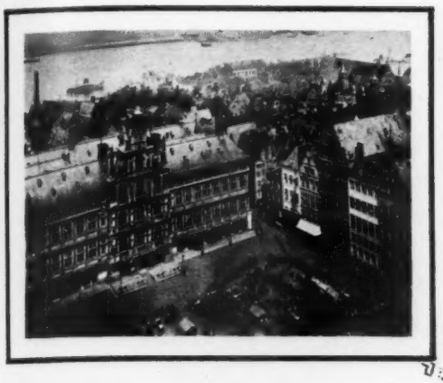
Courtesy, Red Star Line

Antwerp as it appears from one of the ferry landings at Ste. Anne, on the opposite side of the Scheldt.

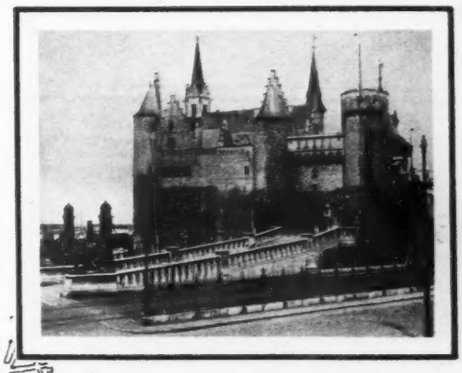
How Antwerp is Building Two Tunnels Underneath the Scheldt

Shafts Are Sunk in Unstable Ground by Use of the Freezing Method

R. G. SKERRETT

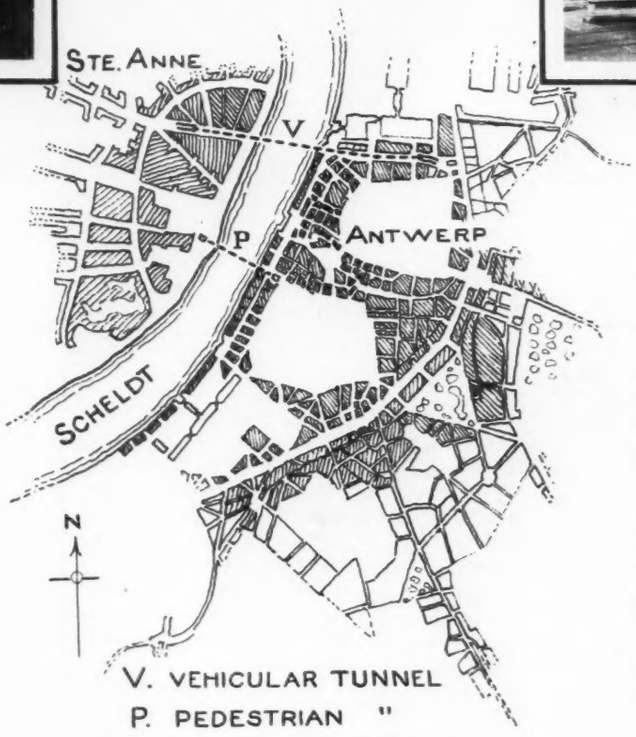


A section of Antwerp and the Scheldt River as they appear from the air.



Courtesy, Red Star Line

Het Steen, built in the tenth century as a part of the Castle of Antwerp.



Sketch showing where the two subaqueous tunnels will cross the Scheldt.

ANTWERP is preparing for expansion by building two tunnels under the Scheldt—the river which links that great Belgian port with the sea, nearly 55 miles distant. The tunnels are of exceptional interest because of some unusual engineering methods that are being employed in carrying forward certain phases of the construction work.

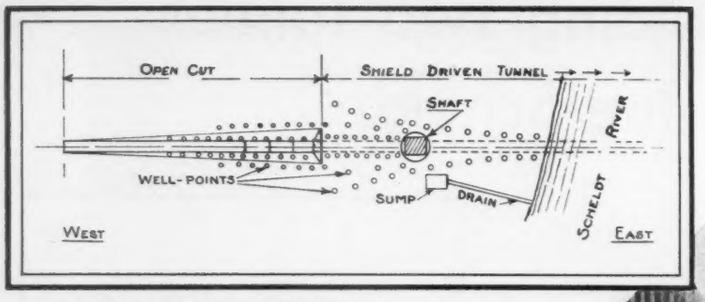
Antwerp was established on the right or east bank of the Scheldt in the seventh century. During the long intervening period the community has continually developed and gained in importance, notwithstanding the repeated ravages of war and the hampering restraints imposed by envious and more powerful countries. Only since 1863 has Antwerp been free to make the most of her commercially strategic location; and in the decades that have followed, her civic authorities and her enterprising men of business have caused her to become an outstanding *entrepôt* for the goods of all nations and a great center for the export of her own commodities as well as those of other European countries. In short, gauged by accepted economic standards, Antwerp is truly Belgium's commercial metropolis.

To serve merchant craft of every sort and size, Antwerp has built extensive quays and numerous tidal basins of splendid proportions; and has provided modern loading and unloading facilities of commensurate capacities. Some of the basins have depths of water exceeding 30 feet, and many of these parts of the inner port are linked with a fine and far-reaching system of canals on sections of which vessels of 2,000 tons can travel. Large ocean-going steamships can moor at the quays of the river port at all stages of the tide. More than 240 lines of merchant craft ply to and from Antwerp. During 1930, 11,002 vessels, totaling 23,465,000 tons, entered the port.

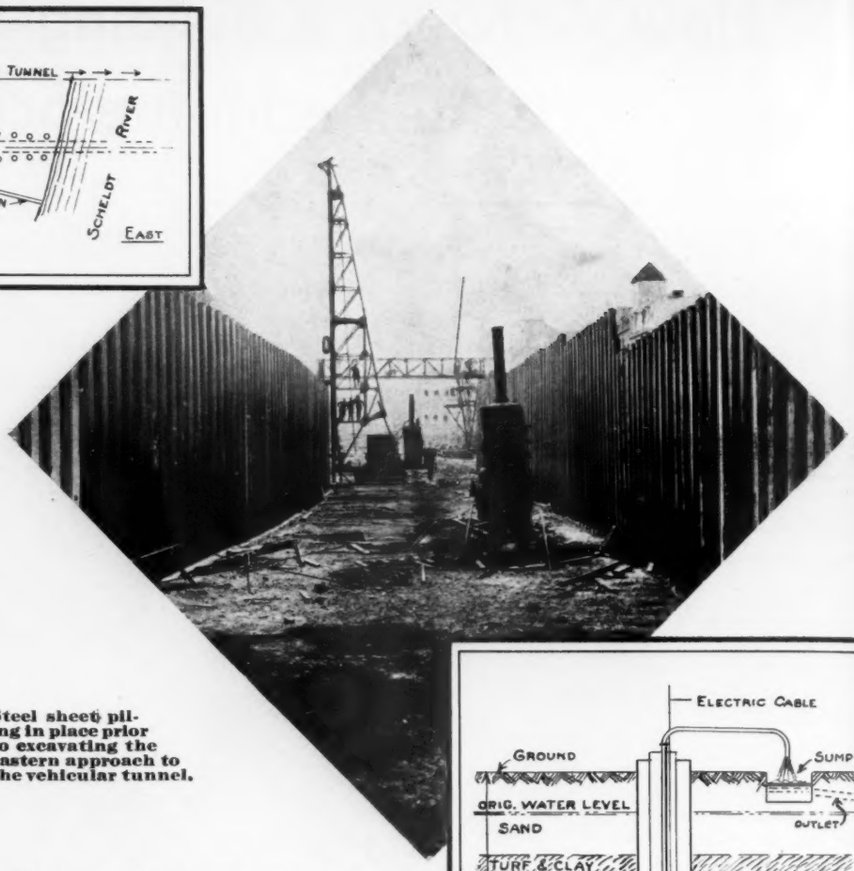
The port's greatest industrial development took place between 1896 and 1913; but Antwerp is still moving forward, although latterly hampered by a lack of space. To accommodate her shipping, the city has spread farther and farther along the right bank of the Scheldt, and to provide space for her growing industries and for the people drawn to her she has extended deeper and deeper into the hinterland northward by absorbing outlying villages. Many of her factories have re-established themselves in these suburbs; aristocratic homes in the heart of old Antwerp have been transformed into banking houses and other places of business; and less pretentious habitations have been remodeled to afford living quarters for a greater number of residents. But even with these radical changes, Antwerp has become overcrowded; and the upbuilding of the outskirts has its drawbacks. In 1900, Antwerp had a population of 365,000, while in 1930 she had 485,000 persons.

More than a hundred years ago, Napoleon Bonaparte declared that Antwerp should spread to the west bank of the river—unpromising as the area appeared for that purpose; and now, thanks to modern engineering, this move is underway. Thus, instead of continuing to go farther afield for space—with the incidental loss of time and added cost of transportation—Antwerp will shortly be able to provide homes and industrial sites close to the center of her commercial activities. A great tract of land has been purchased for this purpose on the west bank of the Scheldt; and the two tunnels now under construction will make rapid intercourse possible. The only neighboring settlements on the west bank are the quaint old villages of Sainte Anne and Tête de Flandre, both of which will be wiped out or absorbed by the projected developments. These two places are at present reached by small ferryboats.

The spreading of Antwerp to the west bank of the Scheldt brings to a close fully half a century of agitation and the preparation of innumerable plans by a succession of engineering experts, none of which was able to win support. Year by year the need of a solution became more pressing. Finally the government, coöperating with the provinces of Antwerp and East Flanders and with the City of Antwerp and other interested communities, created a representative organization to arrange for the construction and maintenance of a tunnel that would link Antwerp with the west bank of the Scheldt.



Plan of one end of the vehicular tunnel, showing how well points were used for dewatering the ground.



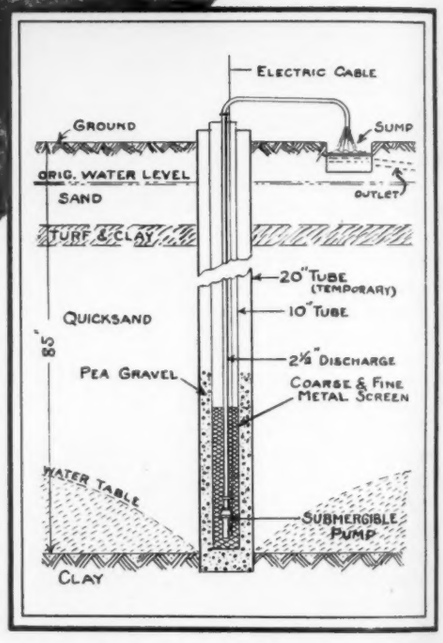
Steel sheet piling in place prior to excavating the eastern approach to the vehicular tunnel.

The Scheldt, abreast of Antwerp, is 1,500 feet wide; and because the tidal range averages 16 feet the river is swept by strong currents. Nothing could be tolerated that would hamper shipping; and so bridges were not favored. A subaqueous tunnel seemed the logical solution; and to make doubly sure of this the society sent Mr. Thonet, an eminent engineer, to the United States to study its underwater vehicular tunnels, built or building. Later on, American consulting engineers played important parts in perfecting designs and methods for the Scheldt tunnels.

Bids were advertised for in the spring of 1930, and in September following eleven European firms submitted sixty alternative proposals. After approximately four months of study the award was made to the well-known firm of Pieux Franki, of Liège, whose plans and specifications had been prepared in collaboration with Messrs. Parsons, Klapp, Brinckerhoff & Douglas, an eminent engineering firm of New York City, and with Ole Singstad, tunnel expert of the Port of New York Authority. The primary requirement was a means by which both vehicles and pedestrians could move from shore to shore; and a choice had to be made between a single tunnel large enough for the twofold service and two separate tunnels. Careful analysis disclosed that two tunnels could be constructed at a lower cost than one tunnel. The pedestrian tunnel is located about half a mile upstream from the vehicular tunnel.

Both tunnels are being driven by the shield method—a single shield being used for each; and they are being lined with rings composed of cast-iron segments. From portal to portal the vehicular tunnel will be 5,800 feet long, and from street grade to street grade 6,922 feet. Its external diameter is 30 feet, 10 inches; and the 22-foot roadway will permit of two lanes of traffic moving in opposite directions. It is estimated that 1,000 vehicles an hour will be able to travel over either lane. The gradient of the approaches will be 3.5 per cent, and of the middle-length section 1 per cent. The shield-driven, metal-lined part will be 4,052 feet long, and at each end there will be a reinforced-concrete section terminating at the portal leading to the open-cut ramp. Following American practice, fresh air will be distributed by a duct under the roadway and vitiated air will be drawn off through a duct in the top segment above the roof slab. At its lowest point, the roadway will lie nearly 90 feet beneath mean low water.

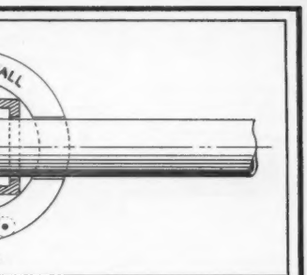
The pedestrian tunnel will be 1,750 feet long between the two terminal shafts which will facilitate entrance and exit. Its outside diameter will be 15½ feet; and its footwalk will be 12 feet wide. Each terminal shaft is 117 feet deep, and will be equipped with two double escalators and a single elevator. These are counted upon to move at capacity 16,000 persons hourly. Pedestrians and cyclists will use this tunnel. The tube is horizontal and is being driven entirely through a deep stratum of firm and impervious clay—only the terminal shafts being situated in water-bearing ground. Only part of the vehicular tunnel lies in the same favorable clay stratum—the rest traversing saturated ground that is virtually quicksand. This is particularly true of the ground on the west side of the river where the driving of the vehicular tunnel began.



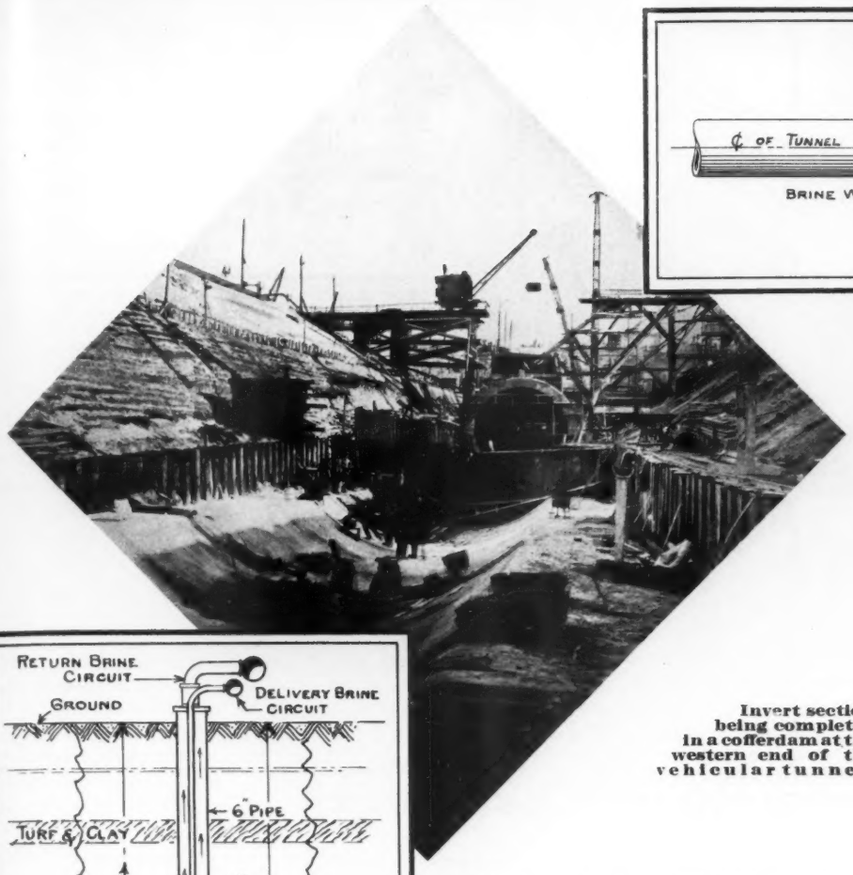
Cross section of a deep well point used for lowering the ground-water level.

The area on the west side is generally low lying, and consists mostly of mud flats and wide stretches of sand. It lies behind a dike that holds the Scheldt at bay at high water; and the visible ground is made up of silt deposited there during the dredging of the river channel. The overburden so formed rests upon a 10-foot stratum of turf and clay that formerly constituted the surface ground; and this stratum now separates two water tables. Before the contractor could excavate the long and deep open cut for the west approach to the vehicular tunnel it was necessary for him to find a way to lower the water tables and thereafter to keep the ground water under control until the approach was completed. The open cut is 1,200 feet long, has a maximum depth of 70 feet below the normal ground-water level, a width of about 40 feet at the deepest section, and an average top width of 120 feet above the cofferdam in which the reinforced-concrete part of the tunnel has been constructed. Its excavation entailed the removal of 200,000 cubic yards of material.

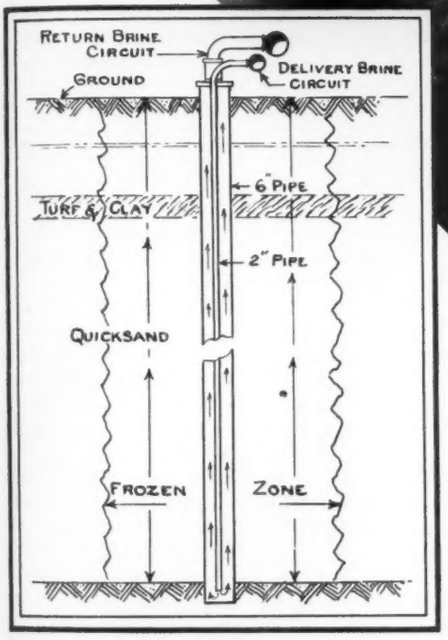
The size and depth of the open cut made cofferdamming prohibitive, and a less costly method had to be employed. The means resorted to were unusual, although previously utilized successfully during the construction of the monumental Kruisschans Lock—one of the notable engineering features of the inner port of Antwerp—which was built in similar water-bearing ground.



Plan of the vehicular tunnel at the western ventilating shaft, showing the manner of forming the ice wall.



Invert section being completed in a cofferdam at the western end of the vehicular tunnel.



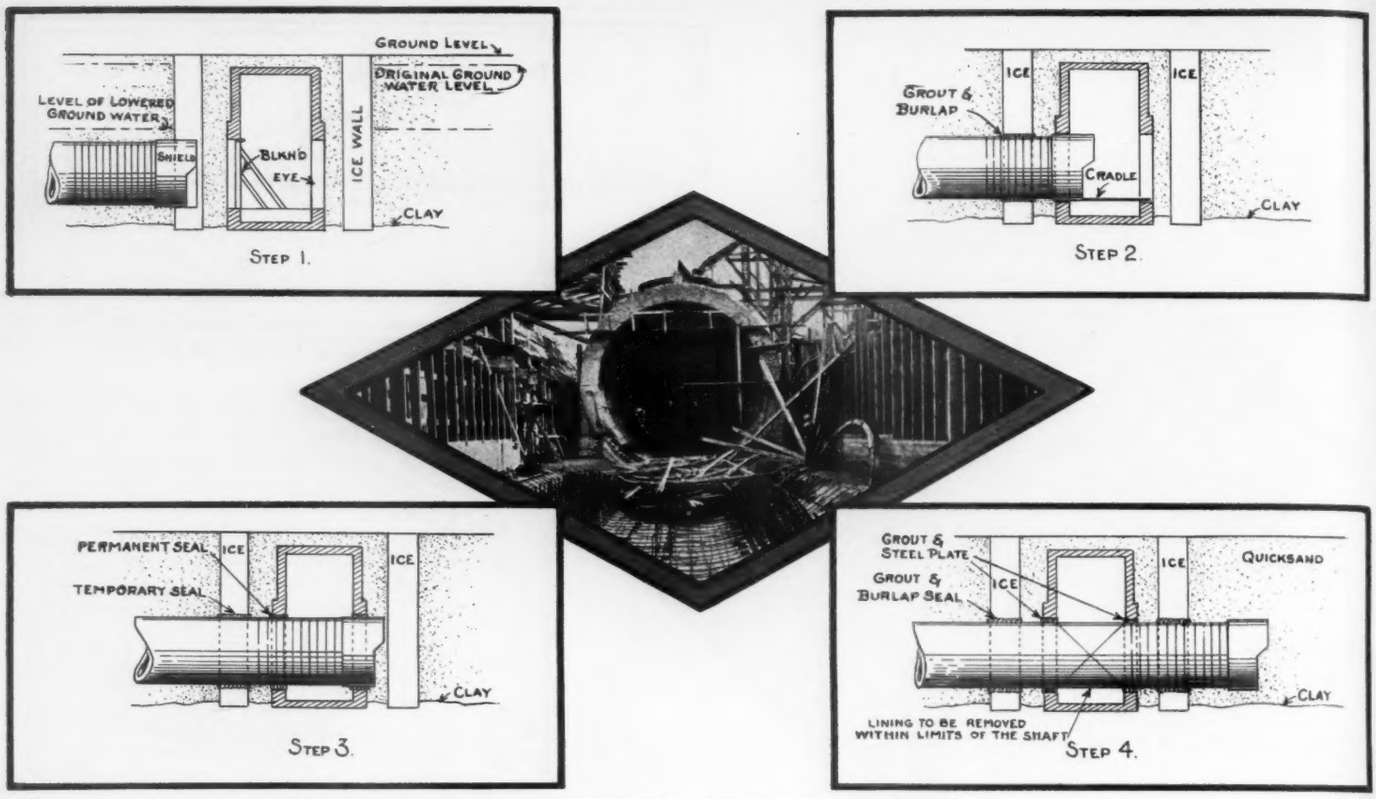
General features of a brine well employed to freeze the ground for shaft-sinking.

The open cut was excavated in three stages: first with a bucket excavator, and then with a dragline and a clamshell bucket. The first two cuts—each 23 feet deep—were dug with sloping banks and with a bench between them. The third was a trench, 20 feet deep, with vertical sides supported by steel sheet piling. For operating convenience and security this bottom trench was divided into a number of cofferdams by driving several transverse bulkheads, also of steel sheet piling. So much for the excavation *per se:* now for the way the water was lowered and the unstable sand was made comparatively stable. The contractor's problem was to lower the ground water in two steps—to drain the water from above the stratum of combined turf and clay and, then, to lower the water table between that layer and the deep impervious clay stratum some 55 feet beneath it. The upper area was largely drained by recourse to screens composed of lines of "well points" connected to a large central pumping plant. This disposed of the water through suitable sluices leading to the river. The remaining water seeped through the slopes of the upper cut and drained into trenches dug in the benches paralleling the center line of the tunnel. These drainage trenches were dug in the relatively firm turf-and-clay stratum; and the water so collected was pumped up and over the top of the open cut.

Each well point consisted of an intake pipe driven into the ground and enveloped at its lower end by two layers of metal mesh—one coarse and one fine, with gravel and coarse sand surrounding the intake so as to arrest the inflow of fine sand that might clog the screens. The number of well points and their spacing in a given area were determined by the hydrostatic head and the water-bearing character of the ground. When the depth of the open cut exceeded the lifting capacity of the pumps, well points of a different sort were utilized. First steel casings, about 20 inches in diameter, were sunk until they penetrated the deep clay stratum. Again, according to conditions, the casings were spaced at intervals of 15, 30, or 60 feet. Their length was approximately 85 feet. With a casing properly seated, a 10-inch tube, substantially as long, was lowered into it and secured in position. The lower end of the smaller pipe was perforated and enveloped with two layers of wire mesh—one comparatively coarse and the other having 2,000 meshes to the square inch. This filter was supplemented by filling the annular space between the two pipes with pea gravel up to the top of the intake area. As soon as the gravel was in place the casing was withdrawn.

The well point was completed by lowering to the bottom of the 10-inch pipe an electrically driven submergible pump capable of discharging, through a 2½-inch pipe, 75 gallons of water a minute. The well points delivered into surface sumps and drains, from which the water finally dropped into the river. By means of the pumping barriers thus formed the contractor was able to lower the water plane 50 feet and to keep the water under control while pouring the flanking walls and the floor of the open-cut ramp and while constructing the reinforced-concrete tunnel section constituting the immediate approach to the shield-driven part of the tunnel. Lines of well points were placed on each side of the shield-driven tunnel all the way from the eastern end of the open cut to the bank on the west side of the river. The lowering of the ground water contiguous to that much of the metal-lined tunnel also enabled the contractor to reduce the hydrostatic head and, to that extent, keep down the air pressure required at the shield and within the associate pressure section of the tunnel. The same procedure will be followed when the shield climbs up from under the river on the Antwerp side.

The vehicular tunnel has two large ventilating shafts that will be surmounted by two buildings to house batteries of electrically driven exhaust and blower fans. These shafts, as well as the communicating shafts of the pedestrian tunnel, have been sunk in water-bearing ground by means of the freezing process, which is widely employed in Europe. The ventilating shafts of the vehicular tunnel rest upon the deep clay stratum; are rectangular in cross section—having over-all dimensions of 53x56 feet; and from ground level to the underside of their foundations are about 92 feet high. Apart from other advantages, the freezing process has made it possible to sink the shafts without timbering. While a considerable period is required to solidify the ground, still the cost is said to be decidedly lower than if the work were done by any other approved practice. We shall describe the procedure at the western ventilating shaft, which was completed before the



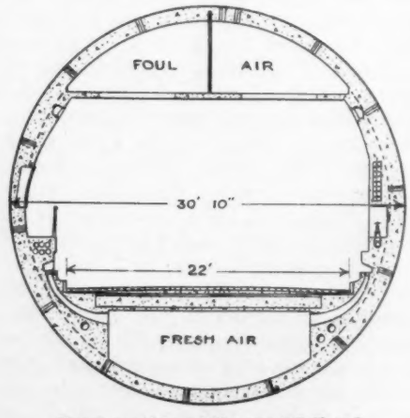
The four drawings show successive steps in advancing the shield through one of the ventilating shafts of the vehicular tunnel. In the center is a view of a concrete section of the bore.

shield had advanced eastward that far.

The freezing operation called for the formation of a hollow cylinder of frozen ground having a diameter of nearly 100 feet and ice walls from 10 to 15 feet thick. This cylinder was rigid enough to withstand the compressive forces of the surrounding water-bearing ground after the unfrozen core was excavated to permit the erection of the reinforced-concrete ventilating shaft. When the shaft was finished, the space between it and the enveloping ice wall was backfilled. In excavating the soft core down to the impervious stratum of clay, the water encountered was pumped out, the same as if working in an open cofferdam.

The cylinder wall was frozen in this manner: on concentric circles, 86 feet and 78 feet in diameter, respectively, were sunk 116 freezing wells which reached from the ground surface a little way into the impervious clay stratum 90-odd feet below. The casing of each well was a 6-inch pipe which was sealed at the bottom. Into this casing was inserted a 2-inch pipe substantially as long but open at the bottom. The central pipe carried the refrigerating brine down to the bottom of the well, whence it ascended by way of the annular space between the two pipes. The intakes of all the 2-inch pipes connected with a delivery main forming a ring at the tops of the wells, and the discharges of all the wells were similarly connected to another pipe ring—the connections being made with lead pipe to allow for expansion and contraction. The delivery and discharge circuits were connected with a central refrigerating plant; and the brine operated in a closed cycle.

The refrigerating plant for the western ventilating shaft consisted of two ammonia compressors, eight evaporators, one condenser, two brine pumps, and two circulating pumps. Its capacity was equivalent to 90 tons of ice per hour at a temperature of 4° below zero Fahrenheit. As the ascending brine swept against the surface of the 6-inch casing it absorbed heat from the surrounding ground and gradually caused the water therein to freeze laterally until the circle of ice from one well joined the circle of ice from each neighboring well—the wells being spaced circumferentially at intervals of from 4 to 5 feet. The freezing operation was started in midsummer, and the ice wall was completed in about four months. The refrigerant used was calcium chloride. The ground was kept frozen until after the shield had passed through opposite walls of the ice cylinder and through two "eyes" left in the bottom of the ventilating shaft for that purpose. Three other refrigerating plants will take care of the work at the eastern ventilating shaft of the vehicular tunnel and at the two communication shafts for the pedestrian tunnel.

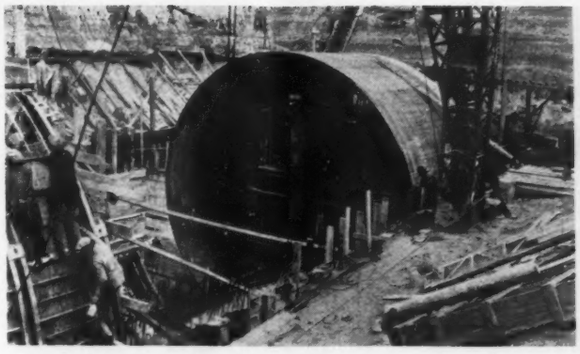


Cross section of the metal-lined portion of the vehicular tunnel.

The following details concerning the manner in which the shield passed through the eyes in the western ventilating shaft of the vehicular tunnel have been supplied by Soren A. Thoresen, resident representative of Messrs. Parsons, Klapp, Brinckerhoff & Douglas: "When the shield reached the west side of the annular ice wall the freezing process was halted and the ice was excavated to within 5 feet of the inner face of that wall. Simultaneously, the intervening space between the ice wall and the permanent shaft was backfilled with clay and the adjacent eye in the shaft was bulkheaded, as indicated by Step I of an accompanying drawing. After the shield was shoved through the ice wall and the clay backfill it landed on a specially designed cradle within the permanent shaft. At that stage air pressure was removed; and, to prevent water from entering by way of the pierced ice wall, an effective seal, consisting of thick grout and burlap bags, was packed in the annular space between the cast-iron lining of the tunnel and the ice wall. Step II illustrates this stage of the advance.

"When the shield had passed through each eye of the shaft, a permanent closure was made between the cast-iron lining and the concrete structure by the use of grout and a fabricated diaphragm. This is indicated in

Step III. The cast-iron lining was maintained while traversing the shaft. This was done so that the shield, after piercing the shaft structure, could again be operated under compressed air when advancing through the fluid quicksand lying immediately to the east of the shaft. At that stage of the work the tunnel to the rear of the shield was closed by compressed-air bulkhead No. 1. Subsequently, when the tunnel had been extended far enough beyond the ventilating shaft to erect compressed-air bulkhead No. 2 so as to permit atmospheric pressure to prevail in the tunnel to the westward of the second bulkhead, then the cast-iron tunnel lining in the shaft was removed and the interior of the shaft completed as planned. The same steps will be followed when the shield reaches the ice wall enveloping the ventilating shaft on the east side of the river."



Shield being erected in an open-cut section of the vehicular tunnel.

The freezing process in the case of the communication shafts of the pedestrian tunnel has followed in principle the procedure just outlined, differing only in some details owing to the particular features of those shafts. Each shaft has two associate inclined shafts—equipped with escalators—that meet at a circular chamber set to the rear of the main shaft and about midway between the ground surface and the bottom of the main shaft in which will run the elevator. Therefore, cylindrical ice walls were formed around the areas to be excavated for the main shaft and the underground escalator chamber. The freezing wells were spaced from 3 to 4 feet apart and extended from the surface to the deep clay stratum. When the two cylinders of frozen ground were completed, they were joined by three straight parallel ice walls also reaching to the same depth—the central wall serving to divide the area into two sections each of which could be independently excavated for its own half of the escalator system. All told, 145 freezing wells were sunk and operated in creating the frozen cylinders and the three connecting ice walls.

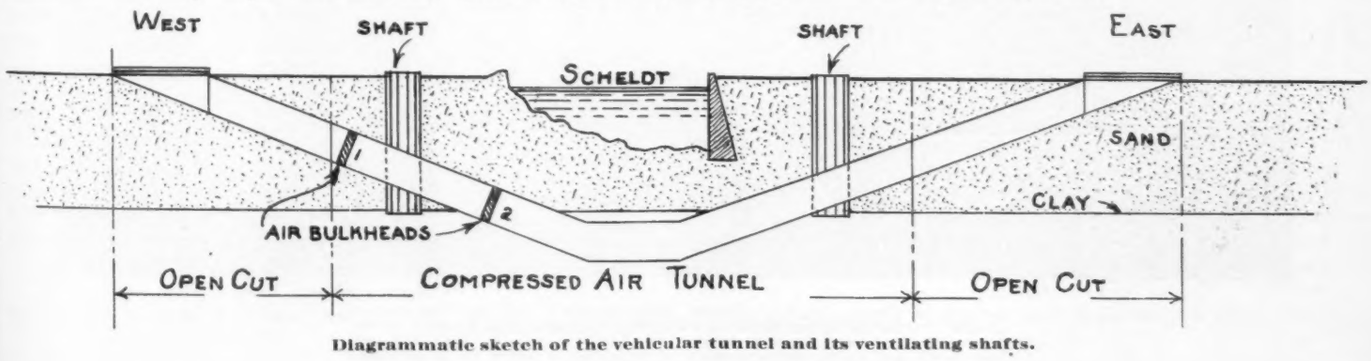
As Mr. Thoresen points out: "The utilization of the well-point system in lowering ground water in quicksand and kindred unstable formations, combined with the freezing method for shaft construction, has brought to the fore a somewhat novel variation in tunnel-building practice, and the results obtained at Antwerp have shown that these means are not only helpful but decidedly economical."

In addition to the refrigerating plant, the contractor maintains a compressed-air plant containing four low-pressure compressors, having a combined capacity of 12,000 cubic feet per minute, and two high-pressure compressors, each of 1,200 cubic feet per minute. All are electrically driven—current for the purpose being purchased. However, the contractor has provided a standby plant consisting of two Ingersoll-Rand oil engines, built by Usines Carels Frères, driving generators having a combined capacity of 500 hp. and capable of supplying sufficient current to operate one of the large low-pressure compressors. A similar plant is furnishing air for work on the pedestrian tunnel. The pedestrian tunnel is scheduled to be ready for service in 1933 and the vehicular tunnel in 1934. The estimated cost of the project is 300,000,000 francs, not including outlays for property acquired on the Antwerp side of the Scheldt. The vehicular tunnel has been driven at an average rate of 10 feet a day.

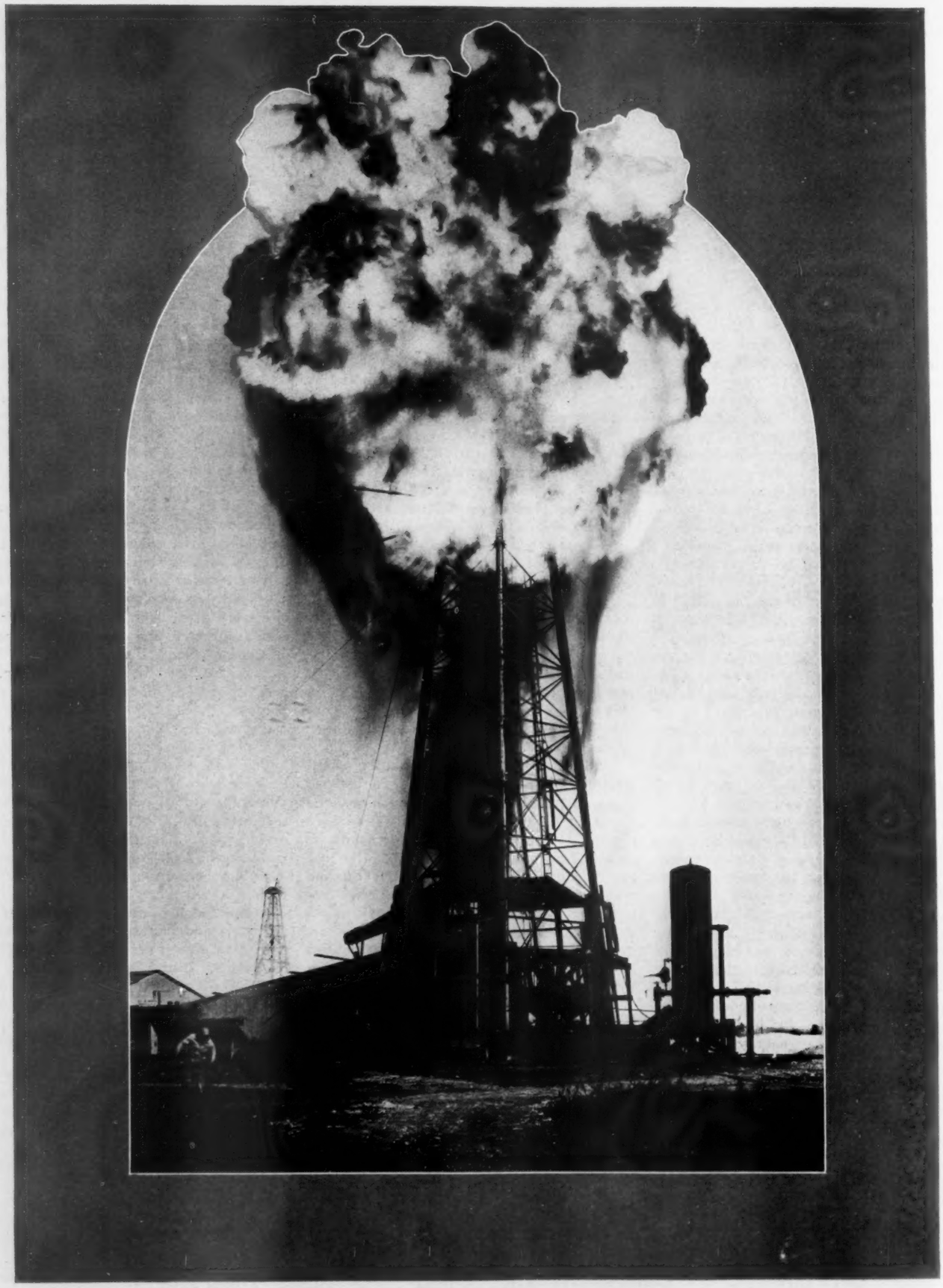
The Foraky freezing process for shaft-sinking has been employed in Europe for years, and has been used in sinking mine shafts attaining a depth of 2,620 feet. Two such shafts, 20 feet in diameter, were sunk at Eysden-Sainte-Barbe in Belgium. In that case, the first 1,700 feet was sunk through water-bearing ground by the freezing process, and the remaining 920 feet was handled in the ordinary manner. In work of this sort success depends largely upon exact knowledge of the position of each underground freezing well. This is understandable because the frozen zones of associate wells must meet in order to solidify the ground and to form ice walls strong enough to withstand the compressive forces of the outlying ground and the hydrostatic head of the water carried by it. There must be some way of ascertaining how far the bore holes for the wells depart from the vertical; and, when this deviation is marked, to know where to sink other freezing wells that will fill the gap. To this end, the Denis-Foraky "Teleclinograph" has been devised.

In some instances, the freezing process has been used only after shafts have been sunk for hundreds of feet before striking water-bearing ground, the object then being to save the work already done and to provide means by which the shaft can be sunk safely to the desired depth. To do this it may be necessary to pierce ground carrying water at high pressure. The first concern is to do the work without reducing the diameter of the shaft. As a preliminary step, a number of diverging holes are drilled outward and downward from the bottom of the shaft. Next the shaft is widened at a point above where the inflow of water is not so serious. A large block of concrete is formed at the bottom of the shaft, and through that plug are passed pipes that will be used as sleeves or guides for the drills to be employed in boring the freezing wells. This work is done through stuffing boxes if the connections cannot conveniently be extended to the top of the shaft. As soon as a hole has reached the necessary depth, the casing for the freezing well is lowered and the central brine pipe inserted. Wherever possible, the well casing does not extend above the concrete plug. This arrangement is preferred because smaller pipes can be used from that point on up to the surface in maintaining the circulation of the refrigerant, thus reducing the dissipation of cold where the pipes are exposed to the air and are not helping to freeze the ground. When the ground is solidified in the manner just mentioned it is technically termed "underfreezing." The freezing operation is continued until solid ground is reached and the shaft has been properly lined to that point within the encircling ice.

Every freezing installation includes thermometers and pressure gages which indicate how every part is performing and what must be done to insure perfect operation. The effectiveness of the method is thoroughly established; and the use of the system in connection with the Antwerp tunnels clearly indicates its flexibility and ever-broadening field of application.



Diagrammatic sketch of the vehicular tunnel and its ventilating shafts.



A well in Ector County, Texas, photographed at the instant it caught fire after being shot. A rock blown against the crown block at the top of the derrick caused the igniting spark. The camera had been set up in anticipation of securing a view of a gusher.

The Oil-Well Shooter
A Picturesque Character

D. D. KLING

AMONG habitual handlers of high explosives there is perhaps no more picturesque individual than the "oil-well shooter." In following his vocation he treads continually upon the border line between life and eternity, in full knowledge that one tottering misstep may spell his doom.

Working as he does in perpetual danger, he becomes somewhat inured to it. As a class he is a fatalist, and a queer one at that. He banks little on the future, which to him is an extremely volatile thing—a cloud that may be swept from the horizon by a wisp of wind.

Statistics are lacking, but oil men estimate that there are approximately 150 "shooters" engaged in their profession at the present time. They are a polyglot lot, drawn from hither and yon. Superficially, they are carefree, devil-may-care men who apparently reap enjoyment from their bizarre flirtation with the grim reaper. Underneath this mantle of levity, however, they are serious-minded, as befits their hazardous duties.

Comparatively few of them are technically educated in a book sense; but when it comes to practical knowledge of explosives and their handling, they are truly experts. It does not require much theory to do the same thing day after day in the same way, and that is their job. Except as to the depth of placing charges, there has been little change in the shooting of oil wells since the days when the first charges were fired in the Pennsylvania fields more than half a century ago.

Experience gained from accidents in which he figures avails the shooter little, for he seldom lives through more than one mishap. He does, however, profit from accidents to others in his calling, and the principal lesson he learns is to exercise the utmost caution in the ticklish work at hand. There are stories extant that the veteran shooter pours nitroglycerine from can to can with about the same concern as a milkman pours milk, but these tales are stamped as pure fiction by those who have spent their lives in the oil fields.

Despite caution, accidents inevitably occur now and then, and they generally mean fatalities. But their frequency is not high when one keeps in mind the numerous oil wells over the face of the earth that are shot to augment their flow. Considering the perils, it is apparent that some guardian angel watches over the destiny of the oil-well shooter.

A well in the Seminole field of Oklahoma flowing oil after being shot with 50 quarts of nitroglycerine.

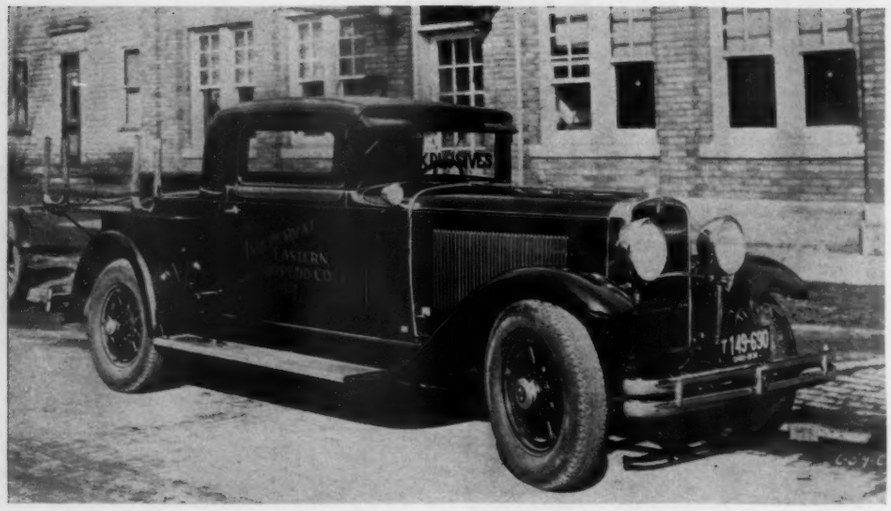
The shooter is largely a product of evolution. Often he starts as driver of the car that hauls explosives and equipment from the magazine to the wells. Such a worker is known as a stock-hauler. He watches the placing and detonating of the shots. Perhaps he is even called upon occasionally to help out in a minor way. There may come a day when one of the regular shooting crew fails to put in an appearance. The understudy is pressed into temporary service, and thus begins his transformation into a full-fledged shooter.

Well-shooting is a special function of the oil-producing industry, and is handled by specialists. Every oil field where shooting is practiced has one or more companies, called torpedo companies, which look after this phase of the operations. They have their own local plants for making nitroglycerine, magazines, transportation trucks, and all needful equipment. They employ their own staffs, and the oil companies engage them whenever their services are required. The basis of payment is usually a flat sum per day for service, plus the prevailing price for the explosives and other materials used.

When a well is ready for shooting, the torpedo company is usually notified a few hours in advance—sometimes not until the morning of the day the work is to be done. The quantity of nitroglycerine to be used is determined, and is obtained from the magazine. It is handled in cans containing 10 quarts each, or approximately 33 pounds.

These cans and the essential equipment are loaded into specially constructed automobiles for the trip to the well. Many of the accidents incidental to shooting formerly occurred in transit. Cans of explosives were placed in the car with only meager protective measures. Now, however, most companies set each can in a rubber jacket or boot. These lessen jarring, prevent friction between the cans, and serve as catch basins in case a leak develops in a can.

At the well, the shell which is to contain the nitroglycerine is hooked to a line of wire or a rope and lowered into the casing until it is at a height convenient for pouring, or it is merely rested on the derrick floor. These shells are commonly of tin, although new ones made of a paper compound have been introduced recently. Each shell has a capacity of 20 quarts. If more than 20 quarts are employed, additional shells are filled. Each shell



A modern car used for transporting explosives and equipment in an oil field.

is lowered into the well separately by means of a line that is played from a reel that may be stationed on the derrick floor or, in some instances, attached to the torpedo company's car which is parked nearby.

The chief causes of premature explosions at the well are the spilling of a small quantity of nitroglycerine in filling a shell and the unhooking of a shell from the line as it is descending in the well. After the shell or shells have been let down, a measuring line is run to make sure that the explosive is bottomed. The shot takes place in the oil-bearing stratum, and its purpose is to shatter the formation and to open up channels in the rock which will facilitate the flow of the oil.

The amount of explosive used varies greatly. The usual range is from 30 to 250 quarts. In the Panhandle fection of Texas, where the oil-containing rock is a compact sandy limestone, shots of 870 quarts, or more than a ton, have often been detonated. Shots of 500 to 600 quarts are fairly common, while at least two of 1,000 quarts each are on record in the Texas fields.

Like most undertakings, nothing happens to mar the peace and tranquillity of the scene if everything goes right. One circumstance occasionally presents itself, however, which calls for action by the shooter. If the well starts a flow of oil or a strong flow of gas while the shell is being lowered, the loaded shells will sometimes be carried back toward the surface. The shooter senses this fortuity when his reel line slackens. But instead of leaving his reel and beating a hurried retreat he has been known to take the opposite course, to rush to the derrick floor. There he stands over the gaping mouth of the casing head with arms arched in front of him. When the shell of explosive rides out of the well, he grasps it firmly, thereby preventing the explosion which would almost certainly result if the shell were allowed to rise into the air and then drop back to the derrick floor.

Incidents of this kind are exceedingly rare. In fact, although the average shooter will claim to have performed the feat, there is only one authenticated instance of the nature on record. Such action on the part of the shooter would not be foolhardiness, however. As he has slight chances of running fast enough to reach a place of security, he would perhaps be playing safer by seemingly electing the more hazardous course.

The shooter is often called in to help put out oil-well fires, and here again he is subjected to extreme dangers. In fact, his adventures are then more thrilling than when following his routine work.

The old-time shooter was subject to superstitions. He had his rituals and his systems. If a certain tool were dropped while preparations were being made to shoot a well, it was regarded as an ill omen. Even a sudden clouding of the sky was believed by some to portend dire consequences. Similar trifling happenings or circumstances were regarded as of great import. The basis for these superstitions usually was the fact that similar conditions had attended previous accidents.

Nitroglycerine has been universally used in the past for shooting. Technicians have recently developed a high-power gelatin dynamite which is being introduced. Its adoption would probably materially lessen accidents. The discovery that the fracturing of oil-bearing rock would increase the flow of wells is accredited to Europe despite the priority of American petroleum production. Pioneer oilmen of this country decided to try shooting, and sent abroad for a small quantity of nitroglycerine for that purpose. It was transported safely across the Atlantic but, so the story goes, a baggageman at the unloading port failed to accord one of the cans proper deference, and the first casualty chargeable to oil-well shooting was registered even before the explosive had reached the well.

For a long time the shooting profession was strongly steeped in tradition. The shooter looked with mild disfavor upon efforts to improve his lot by stripping his work of some of its dangers. He preferred to brush death in the old-fashioned way. This perhaps accounts for the few changes that have been made in procedure and equipment. Many of the improvements that have been introduced were developed outside the ranks of the shooters. New devices for detonating shots and better containers for handling the nitroglycerine were tried out with some reluctance. "These new-fangled contraptions look dangerous to me," was the comment of one grizzled exponent of the calling who had survived twenty years of doing things in the old way.

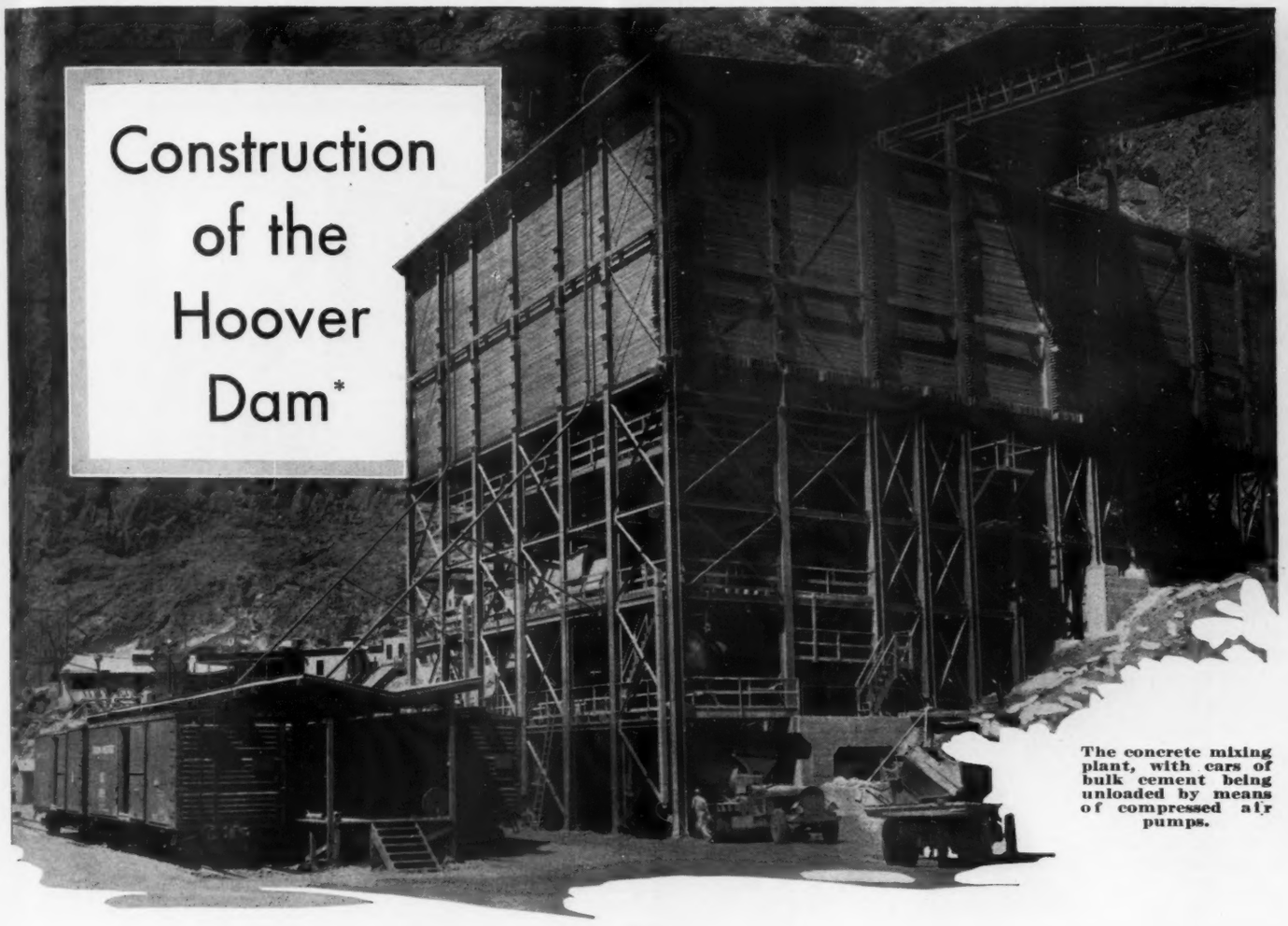
Stories dealing with the shooter's reputed indifference to the risks he runs are legion. Probably most of them are without foundation of fact, but they serve to give an insight into his character. One of these tales has to do with a shooter who was on vacation. He took advantage of his leave to visit a brother who worked in an electric generating station. He was shown through the plant, but was plainly ill at ease and hurried the inspection tour. When they were outside, the brother asked him the cause of his nervousness. "Oh," he replied, "those wires and sparks and whirring machines give me the jitters. They look too dangerous to me!"

Another story concerns a shooter who was bowling along over the uncertain road of an oil field on his way to a job. Shooters usually travel alone, but this one had a companion. In the car which carried them was enough nitroglycerine to blow them into the next county. They were making about 30 miles an hour when a large touring car honked its horn and then whizzed past. The shooter turned to his mate and said, with some concern, "That darn fool had better be careful. That kind of driving is reckless."

The shooter is not an especially well-paid man, all things considered. He averages about $175 a month now, and never was paid much more than $300. Out of his stipend he must lay away enough for surviving dependents, for his life-insurance rate is rather prohibitive.

Pouring nitroglycerine into a shell on the derrick floor of an oil well.

Construction of the Hoover Dam*



The concrete mixing plant, with cars of bulk cement being unloaded by means of compressed air pumps.

The Concrete Mixing Plant Surpasses in Capacity and Refinements any Previous Structure of Its Kind

C. H. VIVIAN

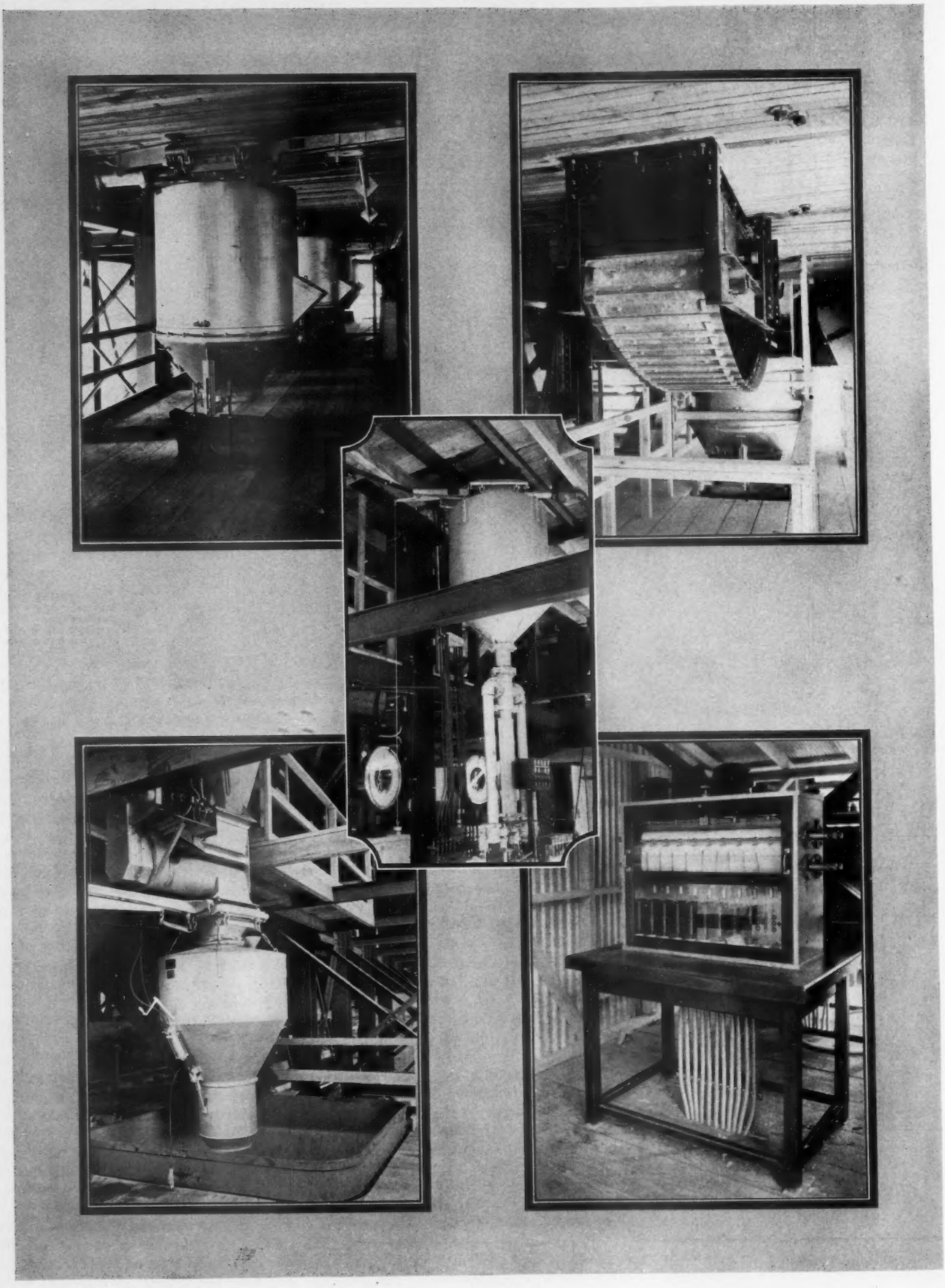
THE BINDING together of the walls of Black Canyon with a great monolithic plug which will halt the rampages of the Colorado River and turn its moisture and energy to the benefits of mankind will call for pouring concrete in huge quantities and at a faster rate than has seldom before been attempted. The tentative schedule of construction drawn up by the Bureau of Reclamation prior to calling for bids allotted 32 months to the monumental task of placing the 3,400,000 cubic yards of mass concrete which will go into the dam proper. In view of what Six Companies Inc. have accomplished by way of speeding up other phases of the Hoover Dam work, it is possible that this estimated time will be shortened somewhat, but even the figure cited visualizes the formation and disposal of more than 3,500 cubic yards of concrete a day. This is equivalent to laying, in the course of 24 hours, a concrete roadway 10 inches thick, 20 feet wide, and more than a mile long, and keeping up this performance every day for 960 days. Even then, this comparison takes into account only the concrete that will enter into the dam structure itself and ignores the 1,000,000 cubic yards of additional concrete which will be used for lining the diversion tunnels and spillways and for constructing the power houses and other appurtenant works. Some of this will be handled at the same time that the dam is being poured. All told, as we have pointed out previously in this series of articles, Hoover Dam will entail the use of more concrete than entered into all the other dams constructed by the Bureau of Reclamation during its 29 years of existence prior to 1931.

Not only are the elements of time and quantity unparalleled, but, in addition, the specifications which govern the making and placing of the concrete are the most rigid and exacting ever to be applied to a large-scale construction undertaking. To further complicate the problem, the concrete must be poured under widely varying climatic conditions, as the inter-seasonal temperature range is commonly well over 100 degrees.

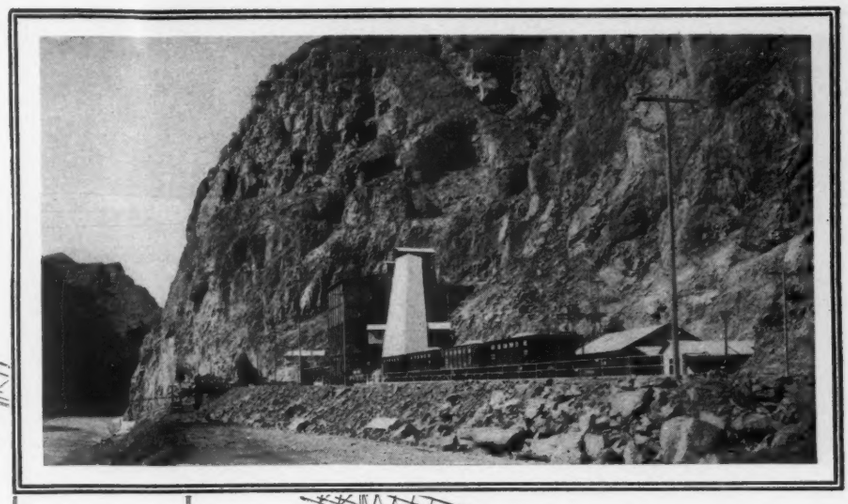
The general specifications of the Bureau of Reclamation provide that the proportions of the mix shall be such as to produce concrete which will have an ultimate compressive strength of not less than 2,500 pounds per square inch for the mass concrete of the dam and not less than 3,500 pounds per square inch for slabs, beams, and other thin reinforced members. In addition to its own painstaking and extensive researches, the Government commissioned experts outside of the Bureau of Reclamation to make thorough studies of such matters as the correct proportions for concrete ingredients, the effect of moisture changes on the shrinkage of concrete, the effect of heat developed in setting and methods of controlling it, as well as of the comparative merits of different types of cement. All of these things, and more, were done to insure that the best possible quality of concrete obtainable will be employed in this enormous artificial rock plug which will equalize the flow of America's most untamable river—a stream that has had a habit of changing within the span of a few days from a placid trickle to a raging, roily, destructive torrent of nearly a quarter of a million cubic feet per second.

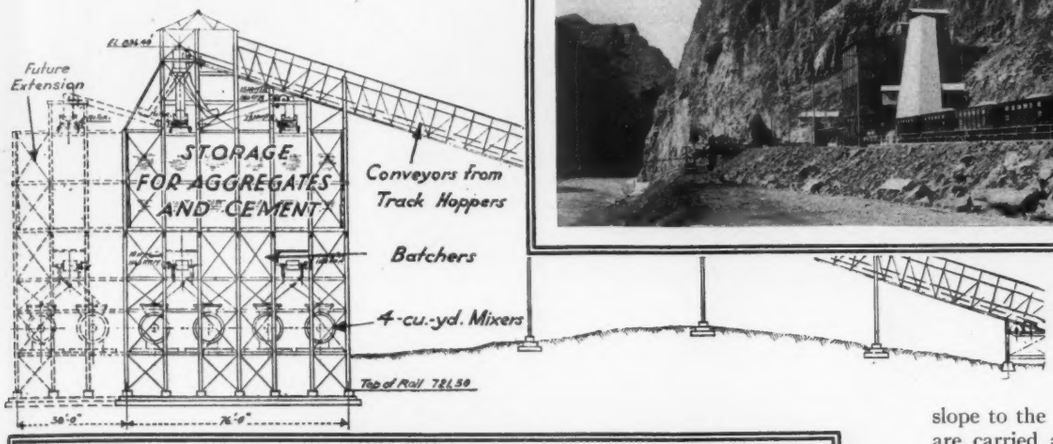
To live up to the exacting regulations governing the preparation of the concrete, it devolved upon Six Companies Inc. to provide not only the largest mixing plant on record but also one which would exceed all previous ones as regards facilities for controlling the uniformity of its product and for insuring

*Eleventh of a series of articles on the Colorado River and the building of Hoover Dam.



Equipment that insures uniformity of mixes. Top, left—Gravel batcher. Top, right—Cobble batcher. Center—Operator's station, with water batcher overhead. Bottom, left—Cement batcher. Bottom, right—Machine that records essential facts concerning every batch of concrete as it is mixed.





At the right is the mixing plant, with cars of aggregates over the track hoppers. At the bottom is the site where the plant now stands. The sketch shows the arrangement of the working parts.

continuity of operation. Such a plant has now been built. It has been operating for several months past to supply the relatively small quantities of concrete being used for lining the diversion tunnels and for miscellaneous purposes. A few months hence, when the river bed has been dried up and excavations for the dam footings have been carried to bedrock, this plant will assume its heavier burden and become the center of activities.

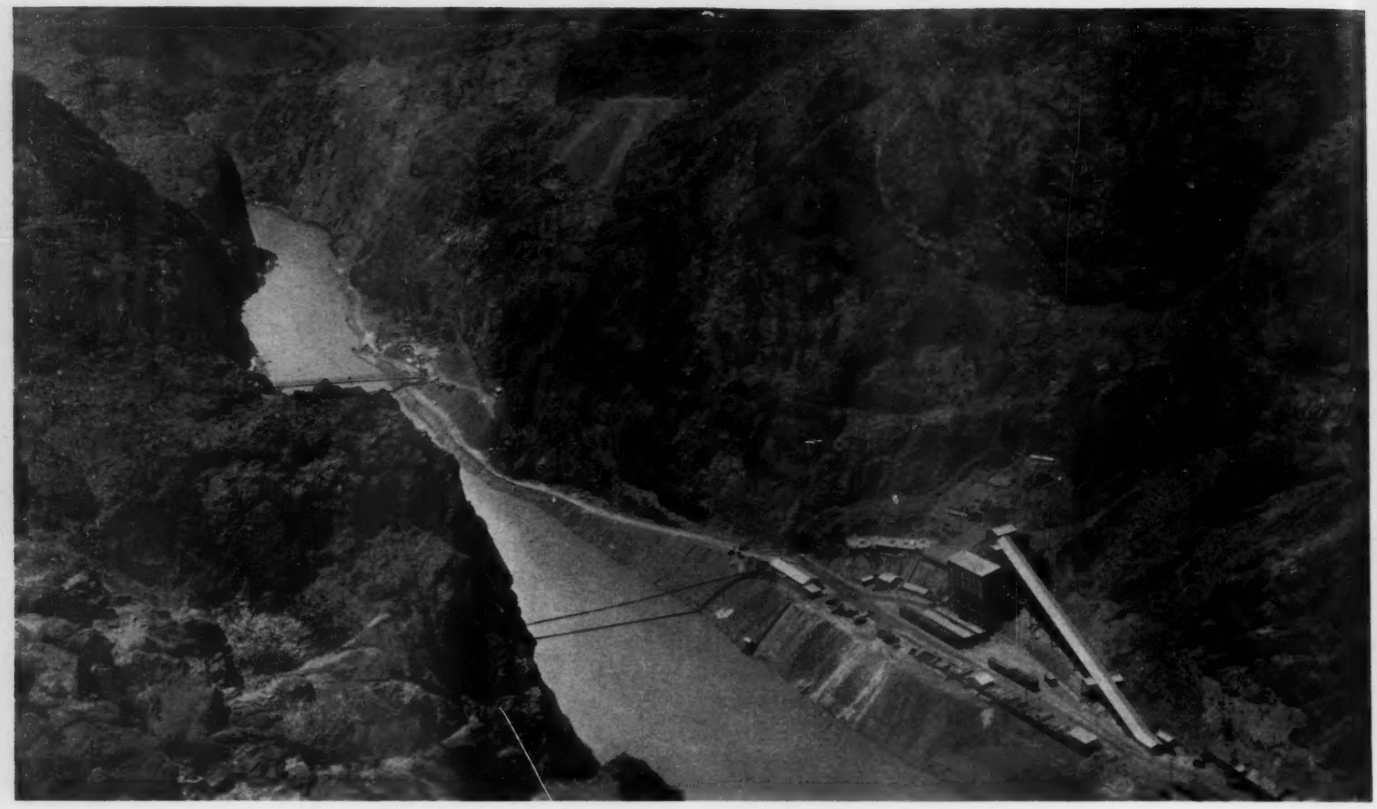
Because of the steepness of the cliffs, the nearest location to the dam site that could be found for the mixing plant was 4,000 feet upstream, on the Nevada side of the river. At this point, designated Lomix on the contractors' canyon railroad system, it was possible, with the aid of rock drills and dynamite, sufficiently to enlarge the natural shelf to accommodate the structures required. From this plant at elevation 720 will come all the concrete for lining the diversion tunnels, for building the power-house foundations and for sundry other purposes, and two-thirds of the concrete for the dam. It is expected that the dam will be built up to elevation 930 or 935 from this set-up, or more than 200 feet higher than the high-water level of the river. After the work has reached that stage of completion, which will likely be sometime in 1935, the concrete plant will be dismantled, transported in units to Himix, on the rim of the Nevada cliff overlooking the dam site, and there reassembled. At that higher level the concrete for the remainder of the dam will be produced.

The mixing plant proper has ground dimensions of 78 by 118 feet and an over-all height of 117 feet, of which the upper 29 feet is a tipple for receiving and handling the aggregates. Upstream from this structure is a track hopper with compartments for the sand, three sizes of gravel, and cobbles, which are delivered there in 30-cubic-yard side-dump railroad cars from the gravel screening plant 4.7 miles distant by rail. To transport these aggregates to the mixing plant there are two inclined belt conveyors which rise on a 16° slope to the top of the tipple. The materials are carried an average distance of 450 feet by the belts, which have a combined capacity of 1,500 tons an hour.

In its present state, the mixing plant contains four 4-cubic-yard Smith tilting mixers, each driven by texropes from a 75-hp. motor. Ultimate plans call for an extension of the building to provide space for two additional mixers of the same kind and size. When this is done, the plant will be able to turn out a cubic yard of concrete every 9 seconds, or nearly 7 cubic yards a minute. This figure is based on each mixer producing 4 cubic yards of concrete every 3½ minutes. Working at this capacity the plant will be able to meet the estimated peak monthly requirement of 170,000 cubic yards by working 16 hours a day, 26 days a month.

The building which houses the mixing equipment is of steel construction and was fabricated and erected by McClintic-Marshall Corporation. Eight hundred tons of steel entered into it. It has laminated timber sides and partitions. Foundations for the mixing plant and the adjacent track hoppers involved the use of 3,000 cubic yards of concrete—which, incidentally, amounts to only about seven hours' output of the plant when it is operating at capacity. The structures were started in November, 1931, and the plant was ready for its test run near the close of February, 1932. The cost of the plant was approximately $250,000 and of the equipment $103,000.

Two railroad tracks run above the track hoppers for aggregates and provide room for spotting 10 cars at a time. Each hopper has a capacity of 300 cubic yards, or 10 carloads, of material. For loading aggregates onto the conveyor belts, there are 4 motor-operated chute gates of special design for each compartment, or 20 in all. Each belt can carry more than one class of material at a time, but in practice this is not done. At the top of the mixing plant, where a full view of all operations may be had, is a station where all the



View downstream from the Arizona canyon rim showing the mixing plant and, left of it, the upstream portals of the two Nevada diversion tunnels.

belts and gates may be controlled by push button. The system is connected electrically in such a manner that the stopping of any belt automatically stops all others behind it and closes the hopper gates. This eliminates the possibility of material piling up at any point because of the failure of any portion of the system to function.

In the upper part of the mixing plant are storage bins for each of the five classes of aggregates and for cement. The aggregates are delivered from the belts to their respective bins by means of rotating chutes and shuttle conveyors. The cement reaches the plant in box cars in bulk form and is elevated to its storage bin through a 5-inch pipe by either of two 40-hp. Fuller-Kinyon pumps which are actuated by compressed air. The bins and track hoppers combined provide storage for aggregates sufficient for 14 hours of plant operation and for cement for 3½ days. From these figures it is evident that the plant is dependent for continuity of operation upon the orderly functioning of the railroad which delivers the materials.

Water is obtained from the nearby Colorado River. It is first pumped to a 50-foot diameter Dorr clarifier located about a quarter-mile upstream from the plant. After all silt in excess of 500 parts to the million has settled out in this apparatus, the water flows by gravity to a 125,000-gallon tank situated adjacent to and higher than the mixing plant.

The plant contains probably the most efficient equipment ever devised for such an installation to determine accurately the proportions of the various ingredients of the concrete. It is designed to deliver cement within 1 per cent and aggregates within 2 per cent of the specified weights. As reported by J. Perry Yates, office engineer for Six Companies Inc., "it is required automatically to record, visibly and graphically, the time of measurement and the actual quantity of each of the aggregates, of cement, and of water for each batch; it must be readily adjustable for compensating for the varying amounts of moisture contained in the aggregates; and the water added must be weighed within 1 per cent. Also, the recorder must contain a device for indicating and registering the relative consistency of each batch."

Sand and the various sizes of gravel are each dropped through automatically controlled gates, in the bottoms of their respective bins, into a batch hopper or batcher. This batcher is mounted on the end of a dial scale which is connected, through levers and balancing weights to mercoid cut-off switches. By adjusting weights at the scales, the amount of aggregates to be included in each batch can be controlled.

There are two duplicate sets of batchers for the four mixers, each of which serves two mixers in alternation. Each set includes one batcher for sand, one for each of the three sizes of gravel, one for cobbles, one for water, and two for cement. Each batcher has its individual weighing, cut-off, and recorder beams and a full-capacity dial above the beam box.

The gates in the sand and aggregate bins are closed by compressed air. The following explanation of the manner in which each batch is accurately measured is from a description of the plant by W. R. Nelson, assistant engineer for the Bureau of Reclamation at the Hoover Dam: "The mercoid switches, installed on the weight end of the system, are operated by change in position of a glass capsule containing a globule of mercury. The electrical current is broken by two projections inserted at the end of the capsule and may be closed by lowering the end of the capsule containing the projections, thus allowing the electrical current to flow through the mercury globule. One of the controls is termed the 'main-flow cut-off', and the other the 'final-balance cut-off'. When the weight of the aggregates in the batcher reaches about 95 per cent of the predetermined batch, the swing of the beam, on which the controls are mounted, causes the mercury globule in the main-flow cut-off to move away from the two projections, thus breaking the electrical circuit and, by means of electromagnetic coils, closing the gate by compressed air. The electrical current operating through the mercury globule in the final-balance cut-off, by means of a small motor and an air valve, alternately quickly opens and closes the gate to allow small amounts of material to dribble into the batcher until the predetermined weight is acquired, at which time the adjusted position of the cut-off beam breaks the contact in the final-balance cut-off".

The cobble batcher is fed by a motor-

Looking upstream from a point high up on the Arizona cliff, showing the mixing plant and a section of the canyon railroad over which materials move.

driven apron conveyor which has a jog control to dribble the last portion and a final-weight cut-off. A special screw feeder, which also has a jog arrangement for adding the final portion, fills the cement batcher. The amount of water for each batch is regulated by means of a balanced valve which operates either automatically through solenoid control or by hand control, as desired.

The weighed batches of sand and gravel are conveyed to the mixer hopper by a collector belt; the cobble and cement batchers discharge directly into the mixer; and the water flows into it by gravity.

An operator on a stand located above and between each pair of mixers controls their operation. In front of him are signal lights showing when the batchers are filled and ready for discharging. To discharge the contents of the aggregate batchers, he pushes a button. Through the action of an electrical circuit, the doors of the batchers are opened in sequence, thereby producing a ribbon feed to the belt that conveys the materials to the mixer. The discharge gates on these batchers are unlatched by solenoids and are counterbalanced so as to close automatically when the batchers are empty. When these gates latch, they close an electrical circuit which again starts the flow of material into the batchers. Thus the filling of these batchers is entirely automatic and the whole cycle of operation is set in motion when the operator presses the button that empties them. The filling operations can be regulated by hand if so desired and the change to manual operation can be made quickly.

A valve at the operating stand actuates an air cylinder which controls the discharge of the cement batcher and another valve controls the flow of the water which is weighed and waiting. Because of this manually controlled discharge of these two ingredients, the operator can coördinate their introduction into the mixer with that of the aggregates as desired.

To start the mixing of a batch of concrete, the operator first turns on the water. After about 5 seconds he opens the gates of the mixer hopper, which contains the weighed aggregates, and the gates of the cement batcher. These actions permit all the ingredients of the concrete to enter the mixer together. After all are within the revolving drum, mixing continues for at least 2½ minutes, after which the concrete is discharged by tilting the drum.

The mixed concrete is delivered through a chute either to agitator drums mounted on trucks or to 2-cubic-yard buckets, both of which are in use for conveying it to points of operation. Later on it is planned to haul the concrete for the main dam structure in 8-cubic-yard buckets on railroad cars. With this in mind, railroad tracks have been laid; but as the same space is needed for truck haulage, the rails are set in a concrete roadway. The 8-cubic-yard buckets will be lifted from the cars and carried into position by cableway. They will be dumped by means of a trip line.

While one batch of concrete is being mixed, aggregates for the one to follow are being weighed and discharged into the mixer hopper and the cement and water batchers are being filled. The time required to empty a mixer of its charge and to introduce the ingredients for the next mix is never more than a minute. Thus far there has been no occasion to run the plant at more than 40 per cent of its capacity.

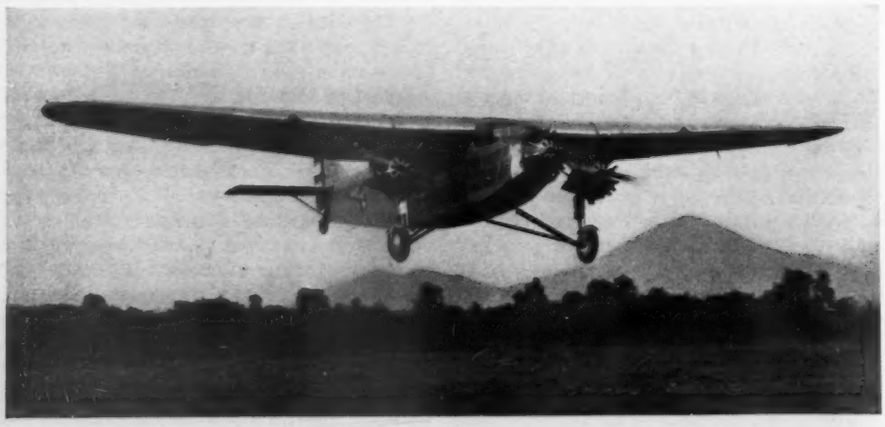
Moisture in the aggregates is compensated for by increasing the individual dry-batch weights by the computed water content, as determined from periodic tests, and by correspondingly reducing the weight of the water added to the mixer.

For each pair of mixers and the batchers that serve them there is an automatic recorder. It bears ten moving pens, arranged side by side, which transcribe a complete record upon a roll of graph paper which moves at constant speed. This record shows the weights of each of the several ingredients entering into each mix in turn and also registers the consistency of each batch and the length of time it was mixed. As the mixer revolves at constant speed and as the power required to operate it varies according to the volume of water in each mix, the power consumption indicates consistency with only small error. The chart furnishes a continuous graphic picture of what is happening in the plant and also provides a permanent record of each batch.

All batching equipment in the plant was designed and furnished by the C. S. Johnson Company, Champaign, Ill.

Peru Takes to the Air and Saves Time

BREESE ROSETTE



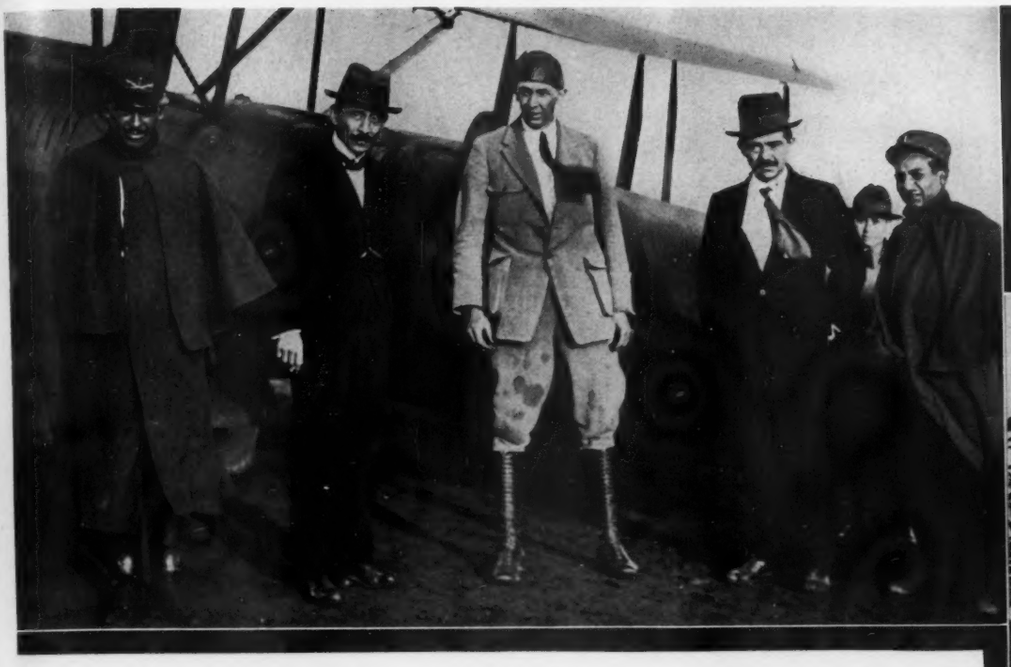
Tri-motored Ford of Peruvian Airways Corporation landing at Las Palmas. Above—Faucett Aviation Company plane in flight near Lima.

THE AIRPLANE has accomplished some amazing things in speeding up travel in various parts of the world, but perhaps nowhere does it make possible greater savings in time than in South America. As a result, aviation has grown remarkably fast in that vast continent to the south of the equator, and the service has reached a high degree of dependability and safety.

The development of commercial flying has been the most effective influence in bringing Peru abreast of the times. In the past, the only means of travel between coastal towns was by steamer or automobile; and, because of the almost complete absence of first class highways, the latter was both slow and uncomfortable. The Grace Line offers service by water between such principal ports as Callao,* Mollendo, Salaverry, and Talara, but the interval between sailings is two weeks. Smaller ports, such as Chimbote, Eten, Pacasmayo and Paita are served by small coastwise steamers which run on weekly schedules, but these craft are very slow.

Thus, until the advent of aviation, mails and passengers could move at little better than the traditional snail's pace. A coastal railroad has been talked about at various times, but economic conditions have been such in recent years that it was impossible to finance such a project. At the present time there are short stretches of railroad connecting cities that are quite close together, but it is impossible to make a continuous rail journey of any length. It seems probable, however, that, when better times come, an adequate highway will be constructed along the coast to accommodate automobile and truck traffic.

Perhaps the best way to show how much the airplane means to Peru is to state that the journey from Lima to Arequipa, which takes approximately 2½ days by steamer and train, is reduced to 5 hours by taking to



Elmer Faucett and his Curtiss "Oriole," just before he made the first flight from the coast to Iquitos in 1922.

Below—Using a Type IM air drill in rebuilding a Faucett plane near Lima.

the air. In 3 hours planes make the trip from Lima to Trujillo, which could not be covered in much less than 36 hours by prior methods of travel. Similarly, the journey from Lima to Talara has been cut anywhere from between 30 and 40 hours to 7 hours.

If one wished still further to emphasize the acceleration of communication which the airplane has wrought in Peru, he need only contrast the modern air-mail service with the messenger system used by the Incas some four centuries ago. The Incas sent messages from their principal cities to the capital city Cuzco through the medium of couriers—native runners who worked in relays. It was a sort of pony express, except that human beings furnished the motive power. Messages were transmitted by means of "quipus," which were strings of colored beads in which the arrangement of beads served as words. An Inca runner would carry the "quipus" from one post to another, where a relief man would receive it on the toss and speed as fast as his legs would carry him to the next post on the route.

There are three commercial aviation companies operating in Peru. Of these, two are private ventures and one is a government line. The Pan-American Grace Airways, which, with Pan-American Airways, Inc., covers virtually all of South America, is known in Peru as the Peruvian Airways Corporation. The Faucett Aviation Company confines its activities to Peru, as does also the National Air Lines, which is a government-owned enterprise.

Pan-American Grace Airways started regularly scheduled flights with mail and passengers in the latter part of 1928. From Lima, where divisional offices are located, it makes two trips weekly to the north and two to the south. Stops are made at all the principal coastal cities, which are, from north to south: Tumbes, Talara, Piura, Chiclayo, Pacasmayo, Trujillo, Lima, Canete, Pisco, Ica, Camana, and Arequipa.

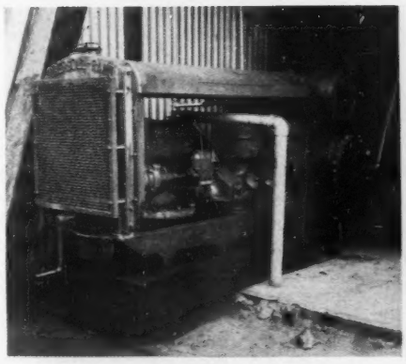
For through service, Ford tri-motored planes are used. Fairchild single-motored planes are employed in local service. On the northern division of the system which extends from Talara, Peru, to Ecuadorian and Colombian ports, Sikorsky amphibians are utilized.

Peruvian Airways Corporation's main shops for servicing planes are at Las Palmas, just outside of Lima. Complete equipment for repair work is installed, and compressed air is used for a variety of purposes including the cleaning out of planes and the operation of paint sprays, sand blasts, small riveting hammers, and small air drills. The air supply is derived from an Ingersoll-Rand Type 20 4¾x4 portable compressor which has been converted into a stationary unit by mounting it on a concrete base. It is driven by a gasoline engine.

The Faucett Aviation Company is the creation of Elmer Faucett, who is president and general manager of the concern. Mr. Faucett was one of the pioneer flyers of Peru, for in 1922, in a Curtiss machine, he made the first trip over the Andes from a Peruvian port on the Pacific to Iquitos on the Amazon River.

This company, in which the Curtiss-Wright Corporation has an interest of approximately 50 per cent, operates only in Peru. It was established in 1928. Flying Stinson-Detroiter planes, it maintains regular schedules between Talara on the north and Arequipa on the south, making the same intermediate stops as the Peruvian Airways Corporation. In addition, it has recently inaugurated service between Lima and Cajamarca, ancient Inca city located in the *sierra* northeast of Trujillo.

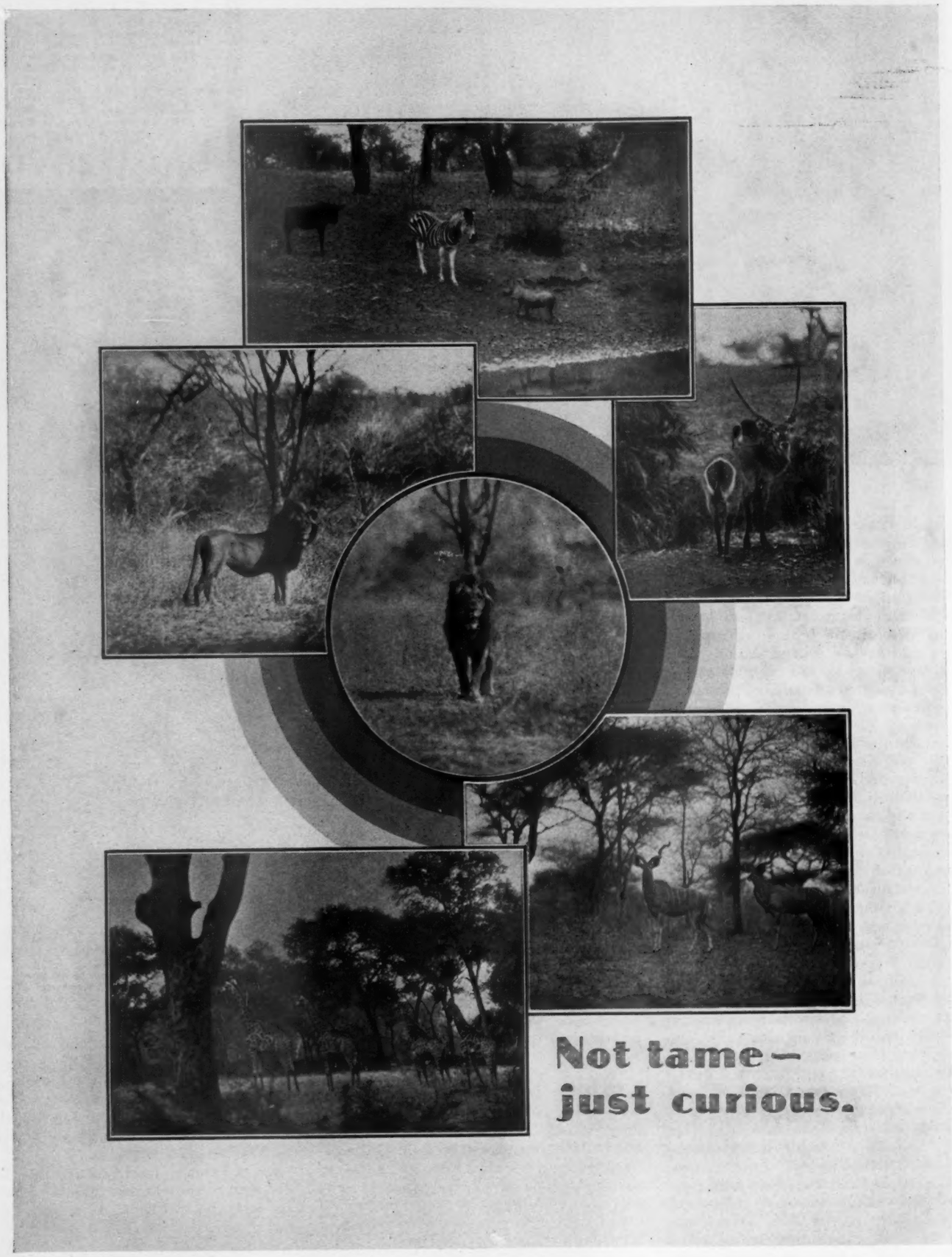
Main shops of the company are at its flying field adjacent to the City of Lima. They are



Type 20 compressor that serves the main shops of Peruvian Airways Corporation at Las Palmas.

equipped to repair planes and to rebuild planes as well as engines. As in the case of the shops of the Peruvian Airways Corporation, compressed air is called upon to perform a multitude of services. An Ingersoll-Rand Type 14 belt-driven compressor furnishes the necessary air.

The government-owned National Air Lines flies army planes and handles all local air mail and some passengers. It also maintains a weekly service for mail and passengers between San Ramon, which lies just over the eastern slope of the main *cordillera*, and Iquitos on the Amazon River. Main shops are at the government landing field at Las Palmas.



© P. W. Willis

The camera caught these wild animals of South Africa in inquisitive moods. At the top are a wildebeest, a zebra, and a wart hog. Below them are two lions and, at the right of these, a water buck. At the bottom are a group of giraffes and, at their right, two koodoos.

Troops in France being trained to repel a gas attack.

Charles Phelps Cushing Photo.

Pneumatic Tubes May Help Fight the Next Big War

Underground Carriers are Believed Practicable for Moving Food and Supplies to the Front Line Trenches

HAMILTON M. WRIGHT

AS WAS demonstrated to the general staffs of both the Allied and Central powers in the closing stages of the World War, future warfare will, by every indication, be conducted in the sky and from bases deep underground, with little actual surface fighting.

Air conflict, of course, can be and usually is conducted from bases far in the rear of the fighting troops and where food, ammunition, and fuel are available. Underground defenses, dugouts, tunnels, and trenches, however, are removed from the rear, but are no less dependent on supplies of food and munitions. The success of underground warfare, therefore, must rely on the continuous and efficient transportation of needed materials from the rear. In the event of another great war, transportation of supplies to the forward lines, it is pointed out, will inevitably be forced underground. Many of the effective agencies of war are adaptations of industrial machines. It now appears that underground transportation, too, will be borrowed from industry and that the pneumatic tube used to carry mail at high speed beneath the streets of New York, Paris, Liverpool, London, and Berlin will be employed to furnish swift and continuous transportation of supplies to sub-surface defenses. The method has already been successfully tested for war use.

A brief resumé of the necessity and development of underground defense in the World War will recall to the reader's mind the conditions which demanded a protected transportation system. It is a bloody page in military history that treats of the first years of the great war, when infantrymen were mowed down like grain before deadly war weapons developed by either side previous to the opening of hostilities. But although modern scientific laboratories had succeeded in creating highly efficient instruments for destroying men, battle strategy had not completely foreseen their devastating effects and, as a consequence, life-conserving devices such as camouflage and intricate networks of trenches were not perfected until later in the war. Armaments were improved at a rapid pace and new ones developed as practical experience gained in the war dictated. Huge guns mounted on railroad carriages aided lesser field artillery in throwing accurate fire on the opposing first-line trenches, fire that pounded them in hours' time to a morass, apparently never touched by the hand of man. After the initial barrage had lifted, nothing remained but a stark area torn by gaping shell holes, some of them 15 feet deep. The effect after two years of fighting was to drive the combatant armies further underground. Dugouts with passageways slanting to the front-line trench and to the rear lines were built, often 75 feet beneath the surface. Here, officers and men could find by day some respite from the nerve-wracking noise of enemy guns and comparative safety from their fire. At night, or just previous to an attack, they would issue forth to the front-line trench or to the line of shell holes approximating its original course either to repair the trench or to attack the enemy.

An aerial photograph of a typical section of the Western Front, in 1916, would disclose two thin lines of paralleling trench from 100 yards to a half mile apart. The barren stretch of earth between them would be discerned as No Man's Land. Behind each

U. S. Signal Corps Photos.

Taking bread up to the front.

Below—Difficulties of transporting materials.

of these first lines and approximately paralleling them up to a mile or more to their rear would be seen four or five other thin lines, all of them connected to one another and to the front lines by series of other lines. These last were communication trenches and were used to move troops and supplies from the country behind up to the battle front.

Little evidence could be detected along each line of trench of the dugouts in which the soldiers lived while stationed there. At this time trenches were dug about 6 feet 8 inches deep and 4 feet wide; and were staggered by sections so that enemy transverse or, possibly, lateral fire could not injure too many men at a stroke.

The World War brought home to general staffs of the contending armies, as well as to the world at large, the fact that an intensive coördination of reliable transportation facilities for the carrying of food and war materials to the front is essential to successful warfare. Well-trained troops and super-fighting equipment mean nothing unless efficient transportation media are at their command. It was necessary to bring up to a quiet sector, from 10 miles to the rear, at least 250 tons of supplies daily to satisfy the requirements of 18,000 men. The French army used trucks, sturdy little Arabian mules, and, in the communication trenches, the backs of men to perform this service. Often, after a German observer had located a supply caravan, a few well-directed shells would smash it to bits and thus seriously interrupt and delay the delivery of precious supplies to the intrenched forces. Not infrequently, enemy barrages would isolate whole sections of the front lines for three or four days and make it physically impossible to get sufficient food or ammunition to the beleaguered defenses.

Near the end of the war a major of engineers of one of the allied nations investigated the possibility of using underground pneumatic tubes to convey food to front-line troops from kitchens in the rear. He had been fighting in a sector where it was impossible to get even mules to the front. While there he had conceived the idea of employing pneumatic tubes. He took the matter up with his superiors and was commissioned to investigate and report upon the plan. His experiments were conducted with the Government-owned pneumatic tube lines between the Custom House and the Appraiser's Warehouse in New York City. Loaded containers weighing 100 pounds, gross, were shot through the tubes. Provided with charts and specifications, including those for a short emergency tube system to deliver 15 tons per hour, the major left for Europe. But the Armistice came before his reports were acted upon. No objection is expressed to making public now the unique project to shoot food or surgical supplies at high speed to troops in the front lines.

The contribution that such a service would offer to the morale as well as to the physical well-being of troops at the front was an important consideration. If laid deeply enough below the surface of the ground, say 20 to 30 feet, the tube lines would be safe from at least moderately heavy gun fire and, considering the fact of their concealment from enemy observers, their destruction could not be caused by directed fire. One of the vital lessons learned in the war was the need for camouflage and secrecy in establishing dugouts, gun positions, and lines of communication.

Engineers confirmed the practicability of pneumatic tube systems for the uses contemplated and suggested certain essential modifications. Since containers would be sent only one way—never returning from the front—they would be made of lighter materials than those used commercially, and thus carry greater loads. The release of compressed air from the tubes into a dugout or other enclosed space would tend to prevent the entrance of poisonous gases by specific gravity. Advancement into territory taken from the enemy would require emergency tube lines that could be laid overnight. Any

Schematic drawing showing how food might be conveyed to the front lines by pneumatic tubes.

Preparing the "chow."

shell happening to explode above the line would of course interrupt service, so engineers advised that such lines be made up of coupled sections of light metal piping, thus making it a fairly easy matter for a rush crew to replace the damaged section or sections with no more effort than the turning of bolts with a monkey wrench.

A brief consideration of the underground tube system which carries the United States mails in Manhattan and Brooklyn will reveal the type of service that brought this method of transportation to the attention of the major and his brother officers as a military expedient, and also its adaptability from an engineering standpoint for modification to war service.

There are 54 miles of pipe lines used in the pneumatic transmission of mail beneath the streets of Manhattan, extending up and down and across both sides of the island between the Battery and 125th Street and across Brooklyn Bridge to the Brooklyn General Post Office. There are between 4 and 5 miles of double tube in Brooklyn. Letters are now carried more than 140,000 carrier miles per day beneath the streets of New York. So expeditious is this service that a bill has been introduced into Congress by Representative Stephen A. Rudd of the Ninth Congressional District, Brooklyn, to extend the tube system from Brooklyn General Post Office to Floyd Bennett Field so as to give the field exceptional facilities for swift handling of mail. The containers in the New York system are propelled through the pipes at a speed of 30 miles per hour by compressed air of 4½ to 8 pounds pressure supplied by electrically operated blowers. Each container is provided with riding rings to minimize friction in passage and to prevent leakages of compressed air. They are filled with about 600 letters weighing approximately ten pounds, and can be dispatched at six-second intervals. Approximately 6,000,000 letters are handled daily by this tube system. Incidentally, 1,500 new containers have recently been placed in service to replace worn ones which averaged 20,000 miles of travel before being declared unfit for further use.

Similar systems, modified to meet varying needs, are in wide usage. Everyone has seen these messengers operating in large department stores and elsewhere. Two notable examples of long and successful service in New York City are the pneumatic tubes in the Stock Exchange and in the Public Library. Both of these systems carry thousands of messages daily and save miles of walking and hours of time.

For war use the carriers would be light and the contents heavy. It would be possible, for example, to send so heavy an object as a 6-inch shell with a riding ring at only one end through a pneumatic tube. For this purpose a $6\frac{17}{32}$-inch emergency pipe line, two miles long, would carry shells or carriers 6 inches in diameter and weighing 100 pounds and would have a carrying capacity of 15 tons an hour. Pressure in this case would be derived from an air compressor driven by a 75-hp. engine. An initial air pressure of 24.7 pounds per square inch would drive the carrier through the tube at an initial speed of 16.5 feet per second, a speed at the end of the tube of 50.6 feet per second, and an average speed of 27.5 feet per second. Thirty-three carriers, each weighing 100 pounds with load, could be kept in the tube at one time—a total of 3,300 pounds in transportation.

These figures are based on an emergency tube line only 2 miles long and laid in quick time. But suppose an army wished to send food 15 miles to the front lines. A theoretical layout, correct from an engineering viewpoint, would provide 2 power plants 10 miles apart: one located in front, say, of the heavy artillery, and one located behind the light artillery. As a matter of fact these plants could even be located beneath the earth and driven by high-speed gasoline engines geared down for power, thus taking up very little room. Each fan or blower would require 93.4 horsepower when under full load.

Eight-inch carriers used in a Goverment pneumatic tube sytem in New York. The insets show mail being placed in carriers in the New York Post Office.

The first power plant would send carriers 5 miles through the tube under pressure. They would then be drawn an additional 5 miles by suction from the second power plant which would, furthermore, shoot them 5 miles ahead under pressure to the front lines. The system would carry 49.6 tons of food per day to the front lines; and, if a double line were extended from the first power plant to the second, it could carry 100 tons per day. The capacity would be limited by the fact that the vacuum system of 5 miles in the center of the two pressure lines would not carry as much as the pressure system. The pulling power of a suction system can never be greater than the pressure of the atmosphere at the earth's surface—in fact, can never quite equal it in a large-scale operation such as this, where a perfect vacuum is almost impossible to attain. The speed of the carriers in the first 5 miles of tube under the pressure system could be no faster than in the second 5 miles under the vacuum system.

In case it was desired to double the line to the second power plant and thus double its capacity, the horsepower would be increased to 120.9 at full load. This would make it possible to transport daily 8,640 carriers containing approximately 100 tons of material, which would be sufficient to supply 7,200 troops.

NEW METHOD OF INSULATING TELEPHONE CABLES

A CHANGE in insulating certain kinds of telephone cables has been effected through the development of a new process that makes it possible to encase 60 wires simultaneously, each in its own sleeve of paper made of Kraft pulp. The equipment that applies the pulp and turns out the finished product is a modified single-cylinder paper machine.

The sixty wires are fed to this machine continuously after passing through an electrolytic cleaner that removes the residual drawing compound. The surface of the mold or paper-making mechanism is divided into as many sections as there are wires so as to form a corresponding number of narrow and continuous sheets. The wires are brought in contact with the mold in such a way that, as the latter rotates and transforms the pulp into sheets, each of them is embedded in its own sheet. From the mold, the paper-encased wires are transferred to a traveling wool blanket on which they are carried through presses for dewatering and consolidating. Next they go to polishers which turn down the sheets and convert them into sleeves that completely cover the wires. At this stage the insulation holds considerable moisture, and this is removed in a box-type electric furnace one end of which is maintained at a fairly high temperature. When the insulated wires are reeled on spools for twisting, the work is finished. The machine operates at a speed of about 130 feet per minute.

The major difficulties that the process presented have been overcome, and it is reported that equipment for the production of about 225,000,000 conductor feet per week has been provided. The cost of the pulp insulation is said to be considerably lower than that of the familiar spirally wrapped ribbon paper insulation, which is being discarded.

Marine Corps Publicity Bureau Photo.

U. S. Marines digging a transport truck out of the mud, 1917.

Thorough Drilling and Blasting Save Money in Highway Work

Rock Can Be Excavated Much Faster if Properly Broken Up

The shovel gets a full "bite" every time it digs into this bank of well-blasted material. Top—Well-blasted rock can be handled by a power shovel as fast as common earth excavation.

There is a lot of work to be done here by the secondary drillers. Bottom—On poorly blasted jobs 50 per cent of the shovel delays are due to the necessity of handling large rocks.

ONE of the surest ways to make certain of low production from a drilling crew on highway construction work in rock is to permit any one of the following to occur: low air pressure at the drills; too soft or too hard drill steels; poorly sharpened or poorly gauged steels; requiring the drill operator to bring up his own steel or to remove a heavy overburden in order to locate the holes. Under many conditions, any one of these can readily reduce production more than 25 per cent; and if two or more of them are allowed to occur simultaneously, production may easily drop to one-half of what would otherwise be possible.

The foregoing points are among the conclusions of Andrew P. Anderson, Highway Engineer of the Division of Management, United States Bureau of Roads, as set forth in the Bureau's publication, *Public Roads*. Mr. Anderson made a study of 71 power-shovel grading jobs which involved the drilling and blasting of rock in considerable quantities. His investigations were based on field reports compiled over a period of six years. Analysis of the assembled data enabled him to break down the process of excavation into its component steps of drilling, blasting, and loading, and to show that the technique of drilling and blasting exerts a tremendous influence upon the rate and cost of moving rock.

"Poor blasting is the rule rather than the exception in much of our highway work," is the somewhat startling statement Mr. Anderson makes at the outset of his discussion. He backs up this assertion with figures from actual jobs to show that, while it is possible by thoroughly breaking up the rock to load this class of material virtually as fast as dirt, the handling of spoils on the average rock job proceeds at a much slower rate than on the average dirt job.

The rate of power-shovel operation, he writes, depends upon three factors: the average time required for the dipper to make the complete cycle; the amount of material handled per dipper load; and the regularity or continuity of operation. Poor blasting usually means large rocks and also, frequently, tight or even some unbroken ground. Large rocks can be handled only with much difficulty and at a very slow rate. Still further delays are often imposed on the shovel while the large rocks are being bulldozed or while the unbroken ground is being reblasted.

On the other hand, he points out, where the blasting has been so thorough that the largest dimension of the larger pieces does not exceed one-half of the smallest inside dimension of the dipper, the rate of shovel operation in rock can be practically the same as that in good common earth excavation. The average amount of pay material moved per dipper load will, however, nearly always be less in rock than in common earth because rock generally takes on more swell from blasting and from being picked up by the dipper than does ordinary consolidated earth.

As the thoroughness of blasting decreases, the rate of production falls off rather rapidly, Mr. Anderson finds. Three years of study of different jobs has shown that the average operating cycle of 1- to 1¼-yard shovels, working in materials classed as well- and fairly well blasted rock, was 23.5 seconds, while the average shovel cycle for the same size and type of shovel operating in poorly blasted materials was 33.5 seconds, an increase of more than 42 per cent. For some very poorly blasted rock which was not included in the foregoing, the shovel cycle averaged 45 seconds—an increase of more than 85 per cent over the time required in well-blasted rock.

Poor blasting also reduces the quantity of material handled per dipper load. For the size of shovels previously considered, the average dipper load was found to be 0.7 cubic yard in well-blasted rock but only 0.5 cubic yard in poorly blasted material—a decrease of more than 28 per cent. Where the blasting was exceptionally poor, the average dipper load fell to 0.4 cubic yard.

The combined effect of a slower shovel cycle and a lighter dipper load is a reduction in the rate of handling of about 50 per cent. In addition to this, more time is always lost where rock is poorly blasted. This is brought out in the following table, wherein it will be noted that shovel stops or delays caused by one item alone—large rocks—increased 100

An abundant supply of well-sharpened and tempered steels of correct lengths should be furnished drillers.

per cent on poorly blasted jobs, while the hourly production during the time the crew was on the job was reduced to less than half that on operations where the blasting was thorough.

The handling of poorly broken rock affects the cost of shovel operation adversely because, regardless of the condition of the material and the speed of operation, the expense of running power shovels is practically constant as long as the crew is on the job. And with the equipment now available, the cost of hauling also is fairly constant. As a result, every decrease in output has a tendency automatically to increase the unit production cost. In support of the foregoing statement, Mr. Anderson cites records of two 1-yard shovels, each with an average operating cost of $21 an hour for the items of loading, hauling, and dumping. During a working period of one week, one shovel handled well-blasted rock at an average rate of 67 cubic yards an hour and the other handled poorly blasted material at an average rate of only 36 cubic yards an hour. The cost of loading, hauling, and placing the well-blasted material was 31.3 cents a cubic yard, as against 58.3 cents a cubic yard for the poorly blasted rock. The difference was 27 cents for each cubic yard. "It seems probable," writes Mr. Anderson, "that if a part of this 27 cents had been expended in obtaining a somewhat closer spacing of the drill holes and in the use of a slightly larger amount of explosive, a considerable saving would have been effected."

Admitting that no two drilling jobs on highway construction are just alike and that there are many variables which must be considered, the data collected indicate that more thorough blasting is possible on a large majority of road-building operations involving the moving of solid rock, hard shale, or similar materials, and that such improved blasting will tend to decrease rather than increase the unit cost of handling the material.

Among the 71 jobs considered were fifteen on which the shovels handled the rock at a rate practically as fast as that usually attained in common excavation. The records show that on one group of operations 48,000 cubic yards of rock was handled at an average dipper cycle of 21 seconds, which equaled the performance of another group of shovels which handled 93,000 cubic yards of common material. The average dipper load was 0.66 cubic yard in common and 0.61 cubic yard in rock. In these cases, then, the rock was handled 92 per cent as fast as the common.

It is Mr. Anderson's opinion that the improper location, spacing, and depth of drill holes are the most frequent causes of poorly broken rock. His observations are that, while the average distance between holes in a given row is three-quarters of the depth of the holes, there is a strong tendency to maintain fairly constant spacing for any given cut regardless of the variations in the depths of the individual holes. He found further that a hole is more apt to be located at a point convenient to the drill runner rather than according to the relative distances to adjoining holes.

When following the average practice of spacing holes on centers equal to three-quarters of the depth of the holes, the drilling cost per cubic yard of pay material increases inversely with the depth of the cut. It is shown that in the case of a 4-foot cut such a procedure may raise the cost of drilling, alone, to more than the bid price for moving rock, while in a 2-foot cut the drilling cost may go up to as high as $4.275 per cubic yard of rock. In light of these facts, Mr. Anderson concludes that "both theory and practice indicate that in shallow cuts it is cheaper to drill proportionately much deeper below grade than in deeper cuts.

"The spacing of drill holes from both the face and from each other," he says, "should be proportioned to the depth of the cut at that point, except that only in the most exceptional cases, where it is impractical to drill the holes at least 4 feet deep, need the spacing of rows ever be less than 3 feet from the face or between rows. For most rock, the spacing between holes need never be less than 4 feet, provided that the total depth of the holes is not less than 4 feet and that they penetrate at least 18 inches below the level to which the material must be removed. In very tough or blocky material, a spacing of over 10 to 12 feet will usually require the drilling of secondary holes to about one-third to one-half the depth of the cut in the middle of an area formed by a hole at each corner. These secondary holes are fired simultaneously with the main ones. This method should give good breakage for cuts up to 20 feet, which probably is close to the limit of the present economic depth of a single lift in most rock.

"As has been indicated, it is usually found advisable to drill the very shallow cuts considerably below grade in order to permit a

Condition of blasted rock for handling by shovel	Average size of shovel	Average dipper load	Shovel production per hour			Percentage of working time lost by shovel owing to large rocks
			Cubic yards	Dippers		
				No.	Cycle	
	Cu. Yds.	Cu. Yds.			Secs.	
Good	1.02	0.68	65.5	96.3	24.4	8.7
Fair	1.08	0.49	38.7	79.7	32.2	14.5
Poor	1.12	0.50	31.8	63.3	36.7	16.3

Stuck drill steels are apt to interfere with progress and to occasion loss in the drill runner's time.

wider spacing and so reduce the drilling cost. While a strict adherence to the rather general practice of spacing the holes three-quarters of the depth of the cut would, in a 2-foot cut, require over 14 feet of hole per cubic yard of pay material, the drilling of 4-foot holes 4 feet apart and 3 feet from the face would reduce the drilling to about 4.5 feet of hole per cubic yard of pay material. The total amount of powder required per cubic yard would be about doubled; but this would be largely compensated for by the saving in blasting caps, wiring, and time of loading.

"The total cost of drilling and blasting a cut as shallow as 2 feet can be still further reduced by additional increases in the depth and spacing of the holes and the amount of explosives. This is especially true of materials which are not very difficult to fragment or shatter properly. In the case of the 2-foot cut just mentioned, increasing the depth of the holes to 5 feet and the spacing to 5 and 4 feet, respectively, would require only about 3.38 feet of drilling per cubic yard of pay material, a saving of about 1.1 feet of drilling at the cost of an increase of about ¼ to ½ pound of explosives per cubic yard of pay material."

The amassed data show that on some jobs in soft or decomposed rock more than 60 per cent of the time the drilling crew was on the ground was unproductive time. The chief delays were due to cleaning holes, changing steels, removing stuck steels, and moving to new hole locations. In igneous rocks, the lost-time percentage dropped to around 48 per cent. The time of waiting for steel, however, became proportionately greater, reflecting the generally rougher country in which such materials are found. In limestone, interstratified with clay seams, lost time dropped to 45.8 per cent. The weighted general averages for all three classes of materials show that lost drilling time was due to the following causes: cleaning holes, 11.1 per cent; changing steels, 8.9 per cent; removing stuck or broken steels, 7.3 per cent; moving to new hole locations, 4 per cent; inactivity of operator, 4 per cent; waiting for steels, 2.6 per cent; mechanical troubles, 2 per cent; springing holes, 1.4 per cent; and miscellaneous, 4.3 per cent.

Pointing out that high air pressure is not in itself a guarantee of a high drilling rate because it may cause excessive breakage of drills and steels in hard rock and an overabundance of stuck steels in soft or seamy rock, Mr. Anderson expresses the opinion that higher air pressures would be productive of greater results in hard and solid rock if some of the current deficiencies could be corrected. He concludes, therefore, that "more attention should be given to perfecting both the steel now used for drills and the methods of heat control and manipulation employed in the drill-sharpening outfits commonly found in highway work."

Long and leaky air-delivery lines do not worry the contractor who makes use of portable compressors.

On the majority of the jobs studied the air pressure at the compressor ranged from 70 to 100 pounds, and on only one was it as much as 125 pounds. However, great losses of pressure were noted between compressors and drills because of leaky pipe lines. On one job, gauge readings showed a drop in pressure of 1 pound for each 16 feet of ¾-inch pipe or hose when supplying one drill at 75 pounds pressure. Pipe lines as long as 1,200 feet were found.

Mr. Anderson notes a tendency to change steel only after each piece has drilled to its full length, despite the fact that in hard rock the bit will often be dulled so much in drilling 1 foot that the time required to drill the succeeding 6 inches will be double that for the first foot of hole. He makes the comment that "about the only time regular changes are made before the drill length has been attained is when the bits regularly lose so much gauge that the following steel will not work readily. And even these conditions are usually blamed on the blacksmith, who is importuned to increase the size of the sharpening die."

Because from 7 to 12 per cent of the total time the drills were on the job was consumed in the operation of changing steels, Mr. Anderson is of the opinion that contractors who have much rock work to do would find it profitable to train operators to make changes in the shortest possible time. A typical stop-watch record of the time required by a proficient drill runner to make the respective changes necessary in drilling a 15-foot hole in fairly hard, uniform granite is as follows: 20, 22, 25, 32, 40, 40 and 47 seconds, or an average of 32 seconds. Thousands of stop-watch readings show that the average time for a change by the usual run of drill operators is 45 seconds for holes from 12 to 15 feet deep, with individual cases ranging from as little as twelve seconds to as much as six minutes.

"The drilling crew," writes Mr. Anderson, "is really only productive when the drills are actually cutting rock. The various operations which interfere with actual production should therefore be reduced to the lowest possible limit. The contractor's interest must not end with simply insuring a high utilization of the available time: he must also see to it that the utilized time is converted into the greatest possible number of linear feet of properly placed and spaced holes. This requires the constant maintenance of adequate air pressure at the drills, together with an abundant supply of properly sharpened and correctly tempered steels of the right lengths within easy reach of the operators."

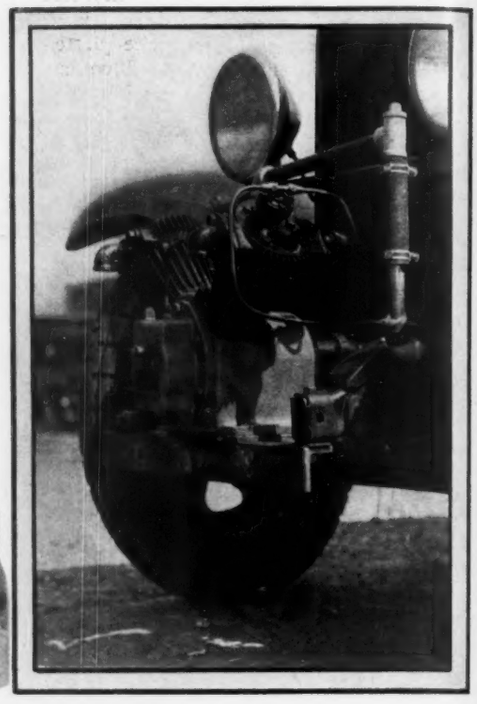
Mr. Anderson discusses blasting at some length and prefaces his remarks with the statement that the amount of explosives required for a given material is generally larger in highway grading than in most lines of rock work, since it is essential that all the material be broken into fragments small enough to permit fast and steady shovel operation. This results from relatively closer spacing of holes rather than from the use of larger single charges. Detailed studies of a number of jobs show that the quantity of explosives used per cubic yard of rock varies from 0.5 pound to 1.9 pounds, the variation resulting from many different factors.

In making shallow cuts it costs less to drill the holes deeper and farther apart than ordinarily.

High-Pressure Air Aids Pavement Patching

LAWRENCE A. LUTHER

Right—Operating the spray gun. Below—Building up expansion joints in a concrete pavement.



Type 30 air-cooled compressor mounted on the front of a standard truck chassis.

THE SCIENCE of building and repairing highways is in a state of continual evolution. As a result of field and laboratory experiments and researches, the purchasing power of a dollar, as expressed in terms of serviceable road, is steadily increasing.

Despite the wide usage of concrete and brick, the demand for prepared bonding agents employed with rock and sand aggregates is undiminished. They are utilized both for constructing new roads and for resurfacing and patching old ones. The oldest and still most common means of applying these liquid bonding agents is by the hot method wherein oils or asphalts are thoroughly mixed at high temperatures with aggregates of the desired size and applied and rolled down before the mixture has cooled. Notable advance in the science of emulsification of asphalt has led to the production of compounds well adapted, under certain conditions, both to construction and repair work by the cold method.

In attempting more fully to exploit the possibilities of these preparations and to improve upon conventional methods of application when used for patching, the Department of Streets of the City of Oakland, California, has developed an ingenious method of spraying the compound used. An Ingersoll-Rand two-cylinder, air-cooled Type 30 compressor is mounted on a light sub-frame which is secured to the front end of the frame of a motor truck. Drive is taken directly from the truck motor crankshaft through a novel mechanism worked out by James Reedy, mechanical superintendent in the corporation-yard garage.

Application of the liquid by air pressure was at first effected by introducing air from a high-pressure tank through a reducing valve at from 4 to 6 pounds pressure into the sealed tank containing emulsion. This produced better pavement at a lower cost than mere sprinkling or pouring by hand. But those in charge believed that closer control of the amount of material used might be combined with more even and penetrating application were it possible thoroughly to atomize the spray by use of an auxiliary air jet supplied with air at a higher pressure. Experimentation bore out their theory and led to the discovery of additional, scarcely anticipated benefits. It was found that the compound could be applied uniformly, no matter how light the liquid content of the spray, and that the atomizing of the solution tended to expedite evaporation and thus to make more practicable the rapid building up of pavement of considerable thickness without danger of leaving a green or oozy patch which might fail to sustain traffic.

The only means heretofore available for cleaning out holes preliminary to repair was to dip and sweep out as much as possible of the disintegrated road material and accumulated silt. This was a time-consuming method and one that could never be more than partially successful, a considerable portion of loose particles always remaining to impair the bonding of the patch to the base material of the road. This was improved upon by developing a light spray gun, 3½ feet in length, whose air and liquid nozzles are controlled by a single trigger. Pressing this trigger part

Pavement-patching truck of the Oakland Department of Streets.

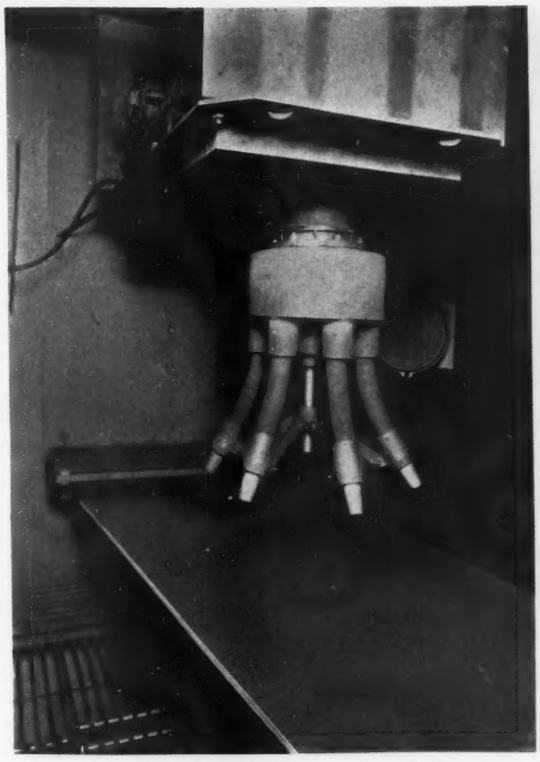
way down opens the air jet. The surface to be coated is thus thoroughly cleaned before the liquid nozzle is opened and emulsion applied.

The bodies of the repair trucks used are equipped with four main compartments: a sealed tank containing emulsion, and three compartments for screenings—one each for coarse, medium and fine, or birdseye sizes. All screening compartments are equipped with trap doors on both sides of the truck and large enough to shovel out material as wanted. The air receiver is mounted on one side of the truck, and a reducing valve is used in the line from the receiver to the solution tank.

After the surface to be repaired is cleaned and coated with emulsion, coarse screenings are spread and sprayed with solution. As the filling process progresses, the medium and then the very fine aggregates are tamped successively into the voids of the coarser underlying material. A dense mass having maximum resistance to compression is thus built up with a minimum expenditure of emulsified binder. In commenting on the efficacy of the spray method, L. H. Taylor, maintenance engineer, remarked, "Controlling the amount of the emulsion and thorough and even application are the secrets of success in this work." Where numerous deep holes in close proximity are to be filled, operators usually accomplish it in two or more lifts, allowing a little time for evaporation between applications.

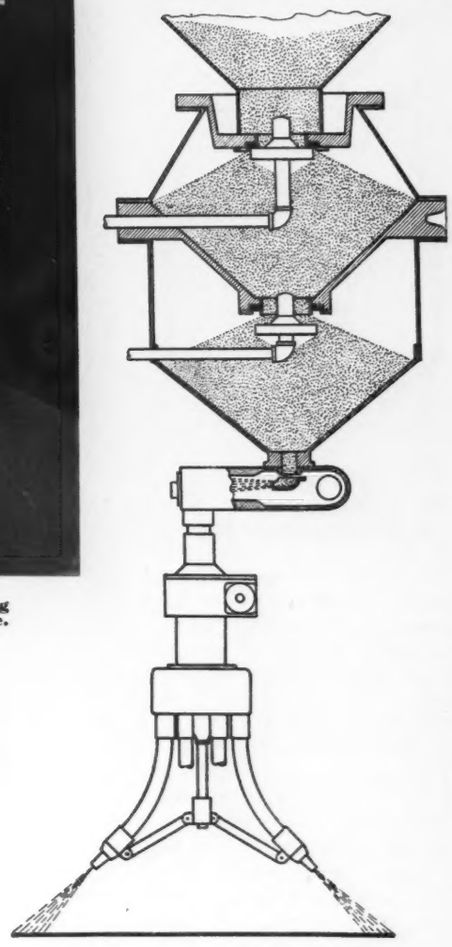
Concentrating all essential equipment in one not very heavy unit makes a certain amount of moving about practicable and is especially advantageous in replenishing the mastic used in expansion joints of concrete highways, a task to which the units are frequently assigned. This mobility in a unit which must cover, with frequent stops, a large amount of territory daily is vital to its success and economy. There is no limiting radius of operation as when a hot-mixing plant is used, and no portable heater or other accessories of hot application are necessary. Only three men are required in the truck crew. Repair work on crowded streets is carried on with little inconvenience to traffic.

"Sorry, Willie, but sand-blasting's the only way to get you clean."



Rotary air gun designed for cleaning steel sheets from 12 to 56 inches wide.

General arrangement of the air-lock feeding mechanism for automatic and continuous service.



Courtesy, The Iron Age

Cleaning Steel Sheets With Abrasives

A NEW order of cleaning steel sheets has been introduced through the development of a blast gun that is automatic in its operation. The gun is the invention of L. D. Peik, chief engineer of The American Foundry Equipment Company, and consists of a rotary head carrying six nozzles made of Carboloy. These nozzles are mounted in flexible tubes that can be adjusted so as to meet the requirements of any width of sheet from 12 inches up to 56 inches. The head is rotated at a high rate of speed by an electric motor. This speed, and the closeness with which the blasts from the nozzles follow upon one another, assure a uniform coverage of the sheet traveling beneath.

For continuous service, the gun is mounted in a sealed, rubber-lined, sheet-metal cabinet which is equipped with a dust arrester and an exhaust fan. The work is fed through the cabinet on power-driven rolls at a predetermined rate. The abrasive is automatically supplied to the nozzles from overhead through a system of air locks, and is fed to them continuously under high pressure. Compressed air is also used in packing the bearings so as to prevent the abrasive from getting into them and scoring them. Because of the special alloy of which the nozzles are made, their orifices are said to remain constant for a period of 200 hours and longer. For intermittent service, a somewhat different arrangement of feeding mechanism is required.

Careful consideration should be given to the question of abrasives, as they must be selected with a thought to the gauge of the metal that is to be cleaned. For sheets of light gauge, steel grit of 50 mesh and finer is recommended, while steel grit of 30 mesh can be used to advantage on gauges heavier than No. 10. Good hard sand of 30 mesh has been used with success so far as the cleaning is concerned; but the life of the sand was found to be comparatively short.

This new method of cleaning steel sheets would seem to possess a number of advantages over pickling, which it has already supplanted in a number of large steel mills.

America's Longest-Span Concrete Arch Bridge

Herman H. Westinghouse cutting a ribbon to open the bridge named for his brother, George Westinghouse.

THE GEORGE Westinghouse Bridge, which, as an engineering accomplishment, has been ranked by some authorities in the same bracket with such undertakings as the Hoover Dam, the Holland Tunnel, and the George Washington Bridge across the Hudson River, was recently opened to traffic. It spans Turtle Creek Valley at East Pittsburgh, Pa., a highly industrialized valley of many railroad tracks and roadways through which travelers over the Lincoln Highway previously had to thread their way. The structure, together with connecting realigned road, eliminates 3½ miles of heavy grades with a resulting saving in time which is estimated at 20 minutes for each automobile. A traffic count indicates that an average of 6,171 motor cars can be expected to cross the bridge every 24 hours. On this basis, the collective saving to the motoring public will amount to three months of time each day.

The bridge is notable as a bold piece of construction and as a structure of grace and symmetry; and it sets a record in that its central span of 460 feet is the longest concrete arch in this country and the second longest in existence. It was started on May 15, 1930, and completed on December 28, 1931. The bridge cost $1,750,000 and the related road improvements an additional $2,250,000. Funds were supplied by Federal, state, and county governments. The bridge was designed by the Allegheny County Department of Public Works. It was built under contract by Booth & Flinn Company of Pittsburgh. The highway work was divided among several contractors.

The bridge is 1,560 feet long and consists of five concrete arch spans: two of approximately 195 feet, two of approximately 280 feet, and the central one of 460 feet. It provides a roadway 42 feet wide. Instead of being built up of one continuous member clear across its width, each arch was constructed of twin ribs at either side. These ribs are 14 feet wide and relatively shallow and have no connecting cross struts between their principal load-carrying elements. This form of construction simplified the concreting, which was accelerated by using high-early-strength portland cement concrete in the keys which permitted the arch centers to be poured in as little as three days. It is estimated that this saved some 95 days on the contract time. The work was conducted on such a close schedule that, on the day following the completion of an arch, forms were in place ready to receive the concrete for the spandrels that help carry the deck. The two arch spans at either end were poured first, and the central arch was thus left until last.

Foundations for the piers and abutments were carried to a maximum depth of 85 feet and involved the removal of 24,000 cubic yards of excavation. The vertical distance from the deepest foundation to the top of the center pier is 285 feet. It had been expected that soft ground would be encountered in sinking the piers and preparations had been made for using compressed-air caissons. These were found unnecessary, however. In fact, so little water was struck that only a small amount of pumping was required.

Twelve railroad tracks and several highways traverse the valley beneath the bridge. To safeguard property from damage and persons from injury, structural-steel sheds were erected over the arteries of travel and

An 18-story building could stand under the center span of this imposing new concrete arch highway bridge at East Pittsburgh.

left in place during the period of construction. These were covered with heavy plank roofing to withstand the force of falling materials.

Construction of the arch members was facilitated by a cableway system extending 1,600 feet from steel towers 110 and 150 feet high erected on opposite sides of the valley. This cableway was capable of carrying loads as great as 30 tons and developed a maximum speed of 2,500 feet per minute. Concrete for the arches and superstructure was handled over this cableway in 5-cubic-yard buckets from a central mixing plant in the lowest part of the valley where aggregates could be conveniently delivered by truck. Piers were poured with concrete supplied by individual mixers. Concrete for the east abutment had to be chuted from the adjacent hilltop a distance of 400 feet to the forms 135 feet lower than the mixer location.

All told, the bridge construction involved 39,000 cubic yards of excavation and the use of 73,350 cubic yards of concrete and 3,700,000 pounds of reinforcing steel.

As the eastern wall of the valley is considerably higher than the western, two deep cuts were required at the east approach and two high fills to cross transverse valleys short distances east of the bridge. The cut adjacent to the bridge is 130 feet deep, while the larger of the fills is 900 feet long, 450 feet wide at its base, and 125 feet high. A concrete tube was built under this fill as an underpass for the East Pittsburgh-McKeesport road.

The western approach to the bridge takes the form of a sidehill roadway, approximately 1½ miles long, which ascends from the valley on an easy grade. At its base it is carried on ramps over street-car tracks and a street which handles local traffic.

Highway engineers for the State of Pennsylvania estimate that this improved and relocated section of the Lincoln Highway will carry 80 per cent of the traffic that now passes through the narrow and winding streets of East Pittsburgh and Turtle Creek boroughs. This will relieve the congestion of local traffic that arises from the great industrial and business activity of the area. Prior to the completion of the improvements, one of the worst bottle necks in the country existed there and it was claimed to be the most difficult section to traverse on the entire course of the Lincoln Highway.

The dedication ceremonies attracted wide attention and were attended by numerous prominent personages. The bridge was named for the late George Westinghouse because of the part he had played in the development of the adjacent territory. His brother, Herman Westinghouse, cut the ribbon which signaled the opening of the structure to traffic.

The site of the bridge adjoins historic ground. Braddock's Defeat of 1755, the Whisky Rebellion of 1794, and other events of national significance took place nearby.

The Edgar Thompson Works, first of the Carnegie steel mills, is on one side of the bridge, and the East Pittsburgh Works of the Westinghouse Electric & Manufacturing Company is on the other side.

Interior and exterior of one of the itinerant laboratories used in making a survey of the milk supply of New York State.

Milk Laboratory on Wheels

TAKING the milk-testing laboratory to the milk sample instead of the sample to the laboratory is a new procedure recently inaugurated by the New York State Department of Health, of which Dr. Thomas Parran, Jr., is commissioner. The last legislature authorized that a survey be made of the present sources of the state's milk supply with a view to introducing more effective sanitary control. In order to cover the territory and to make the large number of tests necessary without the loss of time that would be occasioned by the shipment of samples, two mobile laboratories were designed.

Busses have been adapted for this use by removing all except the driver's seat, leaving a space about 7 feet wide and 18 feet long for the equipment. Laboratory benches have been built along the sides and across the back of each, as well as a sink with running hot and cold water which is drawn from a small storage tank under air pressure. Outside connections have been provided for hose lines so that the supply of water and compressed air can be replenished at any filling station. An electrical unit in an insulated tank serves to heat the water. Current at 110 volts for lighting and for operating the various electrical appliances required for the work is furnished through a meter fitted with long lead-in wires that may be hooked up with an electric power line.

The average daily consumption of fluid milk in homes and restaurants in the state is estimated at about 6,000,000 quarts. About half of this goes to New York City. In addition, from 200,000 to 300,000 quarts of cream are used throughout the state each day. To maintain the standard of these vast quantities of dairy products, the laboratory busses are now busy making the rounds determining the sanitary condition of the larger sources of supply and doing more or less pioneer work in some of the strictly rural districts. After the survey is finished, they are to be assigned to rural areas that are without laboratory service so as to demonstrate to them the importance and value of such a service.

A MODERN SHARPENER FOR WELL-DRILL BITS

New WD sharpener in use.

A NEW, compact, and effective machine for forming and sharpening well-drill bits has been placed on the market by Ingersoll-Rand Company, 11 Broadway, New York. It is known as the WD sharpener. Reports from quarries where this machine has been used indicate that it produces bits which effect a saving of from 50 to 60 per cent in drilling costs and that such bits can be turned out at about half the expense with other available methods.

The WD sharpener follows the principles of design and operation that characterize the Ingersoll-Rand sharpeners which have successfully fabricated bits for piston- and hammer-drill steels for more than twenty years. It is operated by compressed air, and control is centralized in one convenient throttle. Work in progress is at all times in view of the operator. The machine occupies little floor space.

A powerful crosshead delivers the forging blows when forming the bit, and it clamps the steel in position while a dolly, actuated by a cylinder, rapidly forms the face of the bit. Water-channel swages are used to open the channel to the desired shape, thus eliminating the need of chipping or cutting away the metal.

New bits can be forged on blank steels in two or three heats, and dull bits can be redressed in one heat. It is claimed that the WD sharpener makes perfectly formed bits which are concentric with the steel and accurate in gauge and other details. The result is an appreciable reduction in the number of stuck bits and crooked drill holes. Because of these things and because of the greater footage obtained from the bits and of the rapidity with which they can be resharpened, fewer steels per drill are required.

Bits up to 9 inches in diameter on 6-foot by 4½-inch steels can be made on standard WD sharpeners. Dollies can be furnished to make any desired shape of bit.

The addition of the WD sharpener brings the total of Ingersoll-Rand sharpeners to six sizes, each of which is designed to handle steels of a certain size range. The company also makes oil furnaces for heating the steels and a complete line of accessory equipment such as grinders. Details regarding these products may be obtained from any branch office of the company.

BRITISH TRAIN RUNS SEVENTY-SEVEN MILES IN SIXTY-ONE MINUTES

THE Great Western Railway in Great Britain has inaugurated regular service between Swindon and Paddington which calls for covering the distance of 77.3 miles in 61 minutes. This is a reduction of 4 minutes from the previous schedule of 65 minutes. The world's record for railroad speed was established over this same course last June, when the run was made in 56 minutes, 47 seconds.

On the first day that the new schedule was placed in effect the train consisted of eight coaches, or two more than normal. Its gross weight was 249 tons. Three miles from Swindon the speed reached 60 miles per hour and this was increased to 75 miles per hour 7½ minutes after the start. Because of station reconstruction work in progress at the time at Didcot, speed had to be reduced to 50 miles per hour through that point, and it is estimated that this added 1½ minutes to the running time which would otherwise have been attained. As it was, the train averaged 75.85 miles per hour. The maximum speed reached was 87.3 miles per hour.

On the basis of the British train's performance, the rail journey from New York to Chicago would require about 12¼ hours, or about 68 per cent of the fastest time now available under the recently reinstated 18-hour schedule.

WASTE CLAY IMPROVES QUALITY OF PORTLAND CEMENT

EFFORTS on the part of manufacturers to reclaim by-products in order to cut operating costs have led to the utilization of the clay that is used for contact filtration in the treatment of lubricating oils, gasoline, and kerosene. The disposal of this waste clay has represented an item of expense and, not infrequently, somewhat of a problem to refineries that have heretofore been able to employ only a little of it as a packing around transfer lines to retard corrosion and as a foundation under steel tanks and the like. Most of it has had to be dumped.

Mr. J. M. Evans, of the research department of the Associated Oil Company, Los Angeles, Calif., has discovered that by grinding from 3 to 5 per cent of the spent contact clay into Portland cement at the time of manufacture it is possible to turn out a product of superior quality. The cement is claimed to have greater plasticity, making for easier spreading and a smoother finish; to have waterproofing properties that are of value in stucco and in foundation work; and to have increased tensile and compressive strength.

A movement has been started at Pipestone, Minn., that has for its object the preservation in the form of a state park of the local quarries from which some of the American Indians have for years obtained the stone for their peace pipes. Annual pilgrimages for the stone are made by members of the tribes to these quarries, which have long been sacred to the Indians.

APPLYING SOLDER WITH AIR UNDER PRESSURE

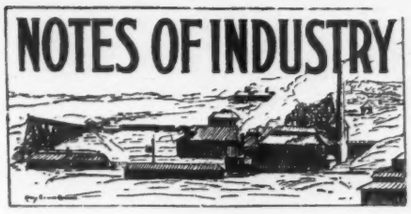
MECHANICS in garages know from experience that every automobile brought in for repair is a rush job. They are expected to do their work well; and yet the average car owner is always in a hurry, he cannot do without his machine. Most automobile repair shops are therefore equipped with every available mechanical means that will enable them to satisfy their customers both as to delivery and quality of the work. One of the newest of these devices which have been invented for his aid is the Ace Metal Spray that has taken soldering out of the hand-labor class.

Since the appearance of the all-steel body, large quantities of solder are used in the making of automobile repairs. Dents, for example, cannot always be taken out by "bumping". When that is the case a filler is needed; and the only satisfactory filler, we are told, is solder. This has generally been applied by hand, a method that is slow and wasteful, and may, besides, cause the metal panels to warp.

The Ace Metal Spray, says the manufacturer, does away with all these disadvantages: It prevents warping and the removal of trim; causes no acid corrosion and no damage to the surrounding paint; and, as compared with hand soldering, saves 10 per cent in time and labor; 10 per cent in solder; and 60 per cent in acetylene. The mechanism is in the form of a pistol, in the muzzle end of which ¼-inch stick solder, inserted through an opening in the top, is fused by acetylene gas drawn from a small tank. The molten metal is atomized and applied by compressed air at from 25 to 100 pounds pressure, depending upon the work to be done. The necessary air can be taken from the shop line or supplied by a small compressor. Both the air and gas consumption are said to be low, the latter amounting to 4 cubic feet an hour. The pistol is adjustable, and can spray as much as 2 pounds of solder per minute. Men soon learn to handle it skillfully and to apply the metal so that it conforms to the contours of the part on which they are working, thus lessening the amount of finishing to be done subsequently.

Filling a dent in the body of a car with solder applied by the new method.

NOTES OF INDUSTRY



France is reputed to be the world's principal source of bauxite.

Conveyor belts are finding favor in metal mines for transporting ore underground.

Another great underwater tunnel is soon to be opened to vehicular traffic. This is the 2¾-mile Mersey Tunnel linking Liverpool and Birkenhead, England.

Of the 25,000,000 acres of oil lands which are said to be in the United States more than 22,000,000 have not yet been proven, according to records of the Federal Trade Commission.

Canada is beginning to occupy an important place in the world supply of the group of platinum metals. Most of these are obtained from the Sudbury district in the refining of nickel-copper matte.

To facilitate stripping ingots, it is the practice in some steel plants to dip the molds, before pouring, in a graphite solution that is agitated with compressed air. It is recommended that the tanks used for this work be provided with false bottoms so as to make them more accessible for the periodic cleaning they require.

A sand classifier of simple design has been added to the equipment made by the Deister Concentrator Company of Fort Wayne, Ind. It is known as the Concenco Vortex Classifier and sizes ¼-inch minus sands for concrete and asphalt, for use in locomotives, and for sand-blasting, filtering, etc. The classifier may be employed singly or in series if sands of different sizes are required.

By means of a dual safety system, a plant in the Pittsburgh district has equipped its cylindrical hot-metal mixers against accidental tilting. To actuate the tilting mechanism the operator has to stand on a platform which, when depressed by his weight, causes a safety switch to be thrown. In case of power failure, an air-driven motor automatically returns the vessel to its upright position.

Much interest attaches to a process for the manufacture of powdered rubber without the aid of chemicals. Its use, it is claimed, will do away with much of the machinery, space, and time now required in smoking sheet rubber and in drying crepe rubber. Powdered rubber can be readily prepared for vulcanization in a rubber-goods factory by mixing it with the necessary fillers and chemicals in revolving drums.

The work of marking cutting tools and pieces of hardened steel stored for machine-shop use is being done in one steel plant by means of a pneumatic device. The steel "pencil" is mounted in an air-driven grinder making 40,000 revolutions a minute. This speed is sufficient to cause the pencil to penetrate the surface of the metal, thus making it possible for the operator to mark the tools, etc., easily, as desired, for purposes of identification.

Transportation by pipe line has many advantages, and these are being recognized outside of the petroleum industry. Down in New Orleans molasses is being conveyed by pipe line; and, if experiments now being conducted by the Lehigh Navigation Coal Company are successful, pulverized coal may soon be delivered long distances in the same way. The plan is to send the coal through the pipe line in a semi-fluid condition and to dehydrate it upon reaching its destination.

A cement exclusively for interior use is the outcome of years of experimenting on the part of Dr. Howard S. Lukens of the chemistry department of the University of Pennsylvania. The new cement is a nicely proportioned mixture of magnesium oxide and magnesium chloride. It is said to be superior to plaster as a finishing material for inside walls because, in addition to all the latter's virtues, it has high tensile strength and becomes as hard as granite.

Spraying coal and coke with Coalkote is said to render them dustless and to increase their burning qualities. Coalkote has but lately been put on the market by the Sun Oil Company, Philadelphia, Pa., and consists of a heavy concentrate which emulsifies with the addition of from 15 to 20 parts of water. The mixture dries quickly after application, and gives the coal a lacquerlike finish. According to the manufacturer, the cost of the treatment varies from three to eight cents per ton of coal.

Photo, Acme

Model of a dirigible which the inventor, C. R. Minor of Wilmington, Del., proposes to propel by compressed air. The design calls for a lighter-than-air craft that can be handled by two men and carry 200 passengers. The model was on exhibition at the recent National Inventor's Congress held in San Francisco, Calif.

The Frood Mine of the International Nickel Company in the Province of Ontario has been equipped with a stench-gas injector to clear the underground workings rapidly in case of fire. The apparatus has been installed at the collar of one of the shafts, and is interposed in the compressed-air line. Two flasks of ethyl mercaptan are always in readiness; and these can be injected separately into the line. Using one flask only, tests have demonstrated that the stench can be made to penetrate all parts of the mine in ten minutes.

Corrosion is said to be a troublesome factor in refining sulphur-laden crude oils and is the cause of shutdowns due to vapor-line and condenser failures. It is therefore interesting to learn that a chemist of the Dixon Creek Oil & Refining Company has discovered that these shutdowns can be largely prevented by introducing zinc oxide into the vapor stream. Months after this method was first tried in a plant near Kingsmill, Tex., the vapor line and the metal condensers showed no appreciable signs of corrosion.

The briquetting of lignite as developed in the Estevan-Bienfait fields of southern Saskatchewan has been advanced an important step, it is reported, through the development of a new process at the plant of the Western Dominion Collieries at Taylorton. The Morfit process, named after C. C. Morfit its inventor, enters into the third and final stage of carbonization, and has to do with the cooling of the coke. As a result, it is possible to store the product, either in coke or briquette form, without danger of disintegration, crumbling, or spontaneous combustion.

Coin-in-the-slot typewriters have been put in service in Germany where they are now to be found in hotels, railway stations, and kindred places for the convenience of the public. Upon the insertion of a 10-Pfennig piece, a little more than two cents in American currency, the machine is unlocked, and the user can strike the several keys 1,000 times before the typewriter is again automatically locked—each stroke being registered on a dial on the coin-operated attachment. As the cost of the service is based on work done and not time the machines are becoming popular.

After considerable research, the Ingersoll Steel & Disc Company, Chicago, Ill., has announced the development of a commercially practicable process for the manufacture of a 2-ply stainless steel. The new metal, which has been named Ingoclad, consists of stainless steel on carbon steel and is made of a composite ingot. The bond between the two metals is said to be a perfect one. It can be substituted for solid stainless steel wherever the cost of the latter would make its use prohibitive. According to the manufacturer, Ingoclad can be deep drawn, stamped, welded, formed, and polished. It is being produced in various gauges and sizes.

AUTOMATIC BOX-MAKING MACHINE

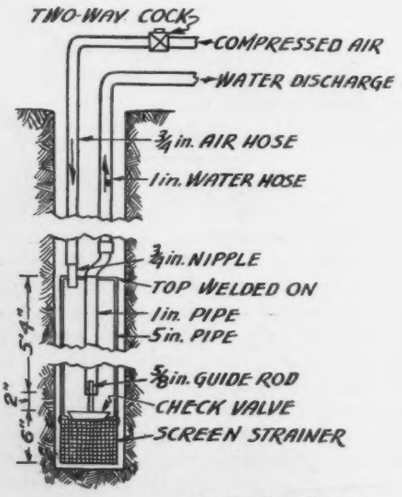
FROM Germany comes an announcement of the invention of a box-nailing machine that should prove a boon to those manufacturers who need something stouter than the familiar cardboard container in which to pack their commodities for shipment. Where many wooden boxes are required, it is now the practice to get them knocked down and to nail them together by hand.

The new machine works automatically. The lumber is fed into one end of it and emerges at the other in finished box form. It sounds like magic; but the United States consular office in Berlin reports that the machine will make any size of case of any thickness of lumber and can turn out 960 in an 8-hour day.

PORTABLE "AIR LIFT" BAILS WATER OUT OF DEEP DRILL HOLES

FOR removing water from deep blast holes before loading, the Consoiidated Quarries Corporation has rigged up an ingenious contrivance at its Rock Chapel plant in Georgia. It consists in the main of an air cylinder, 5 inches in diameter, which is fitted with two hose connections, one for compressed air and the other for water. The drill holes at Rock Chapel are about 90 feet deep and 6 inches in diameter.

The modified air lift is easily carried from place to place, as required; and, with the air cylinder charged, is lowered to the bottom of a hole by aid of the attached hose. When adjusted, the air in the cylinder is released by means of a 2-way valve interposed in the air line. This permits the water in the hole to flow into the cylinder through a strainer set in the lower end of it. When filled, compressed air is again admitted to the cylinder, thus forcing the water out and up to the surface. These operations are repeated until the hole has been "pumped" dry. By this method the drill holes are prepared for loading in a fraction of the time formerly required when a tripod-mounted and hand-winch-operated bailer was used.



Courtesy, Rock Products

Vertical section of a drill hole with the modified air lift in place.

WORLD ECONOMIC SURVEY, 1931–32, by J. B. Condliffe. An illustrated work of 327 pages published by the League of Nations and obtainable in the United States through the World Peace Foundation, 40 Mt. Vernon Street, Boston, Mass. Price, $2.50.

THIS is the first edition of a survey of international affairs that is to be published annually by the League of Nations. The work is based mainly on data collected by the Economic Intelligence Service of the League and has been interpreted by Mr. Condliffe, formerly Professor of Economics at Canterbury College, New Zealand, and at the University of Michigan, as well as Research Secretary of the Institute of Pacific Relations

The first chapters of the book are devoted to the postwar period; the next are given over to an analysis of various aspects of the depression, namely—fall in prices, shrinkage of international trade, balancing of international accounts, changes in the banking structure and policy, wages and unemployment, public finance, and commercial policy; and the last chapter deals with the international measures now under consideration as a means of escape from the crisis.

The author has succeeded in his aim to present in one readable volume a bird's-eye view of the world's economic development—its problems and tendencies.

AUDELS MATHEMATICS AND CALCULATIONS FOR MECHANICS by Frank D. Graham, M.E., E.E. An illustrated book of more than 700 pages published by Theo. Audel & Company, 65 W. 23rd Street, New York. Price, $2.00.

THE purpose of the author in publishing this book has been to show students the way to learning mathematics readily without the aid of a teacher. Starting out with the first principles of arithmetic, he takes up, step by step, geometry, mensuration, trigonometry, algebra, and calculus; and, besides a section on how to use the slide rule, includes the many calculations that are necessary for figuring out mechanical and electrical problems. The subjects are all presented in an understandable and concise form, and in such a way as to arouse the interest of the student. As a means of acquiring a knowledge of mathematics in any of its branches and as a work of reference, the book is to be recommended. It is bound attractively in flexible covers.

MAC'S COAL DIRECTORY AND BUYERS GUIDE, 1932–33 edition. A book of 500 pages, published by the Coal Information Bureau, Union Trust Building, Pittsburgh, Pa. Price, $10.00.

THIS thirteenth and enlarged edition of the directory of the coal trade, which is published annually, includes all the changes made in the coal industry up to August 1, 1932. It is a complete reference book for both the buyer and the seller, and consists of six main sections and numerous indexes. The former deal with coal, collieries, coal-selling companies, operating companies, etc., while the latter list the names and addresses of such companies and of their executives, as well as of mines. A buyers' index is also included. Anyone interested in buying, selling, consuming, mining, and transporting coal and coke, or in selling colliery supplies and equipment, should find this book of value.

INTERNATIONAL TRADERS' HANDBOOK, a volume of 175 pages published by The Commercial Museum, Philadelphia, Pa. Price, $1.50.

WITHIN the covers of the latest edition of the *International Traders' Handbook* is a wealth of information concerning foreign countries that has been especially compiled for the benefit of the exporter, importer, shipper, banker, etc. It is a more complete work than the earlier editions because it contains much additional data regarding foreign and domestic weights, measures, and moneys that was heretofore published separately. Men engaged in international trade will find it a handy reference work and guide.

The New Jersey Meter Company, Plainfield, N. J., has added to its well-known line of DriAir separators specially built units for pressures higher than the 150 pounds per square inch for which the standard DriAir is designed. The new units are suited for working pressures of 400 pounds. Their bodies are of bronze, and other structural parts are strengthened to withstand a hydrostatic test of 1,000 pounds. The float-valve is modified so that the float will open the valve against a working pressure of 400 pounds, with an ample margin of surplus buoyancy. The standard DriAir delivers clean, dry air for the operation of pneumatic tools, rock drills, sand blasts, paint sprays, hoists, motors, etc., where the working pressure is seldom over 125 pounds. However, there are applications—such as in the compression of natural gas for the manufacture of gasoline, etc.—that demand higher pressures, and these applications are on the increase. A bulletin descriptive of the DriAir separator can be obtained from the manufacturer upon request.

Air ejectors for high-vacuum service beyond the range of the ordinary reciprocating vacuum pump are described and illustrated in a new leaflet issued by Ingersoll-Rand Company, 11 Broadway, New York City. These jets are arranged in one, two, or three stages, according to the operating pressure. It is claimed for them that they will handle hot, wet, or dry gases at any degree of vacuum and in almost any quantity.